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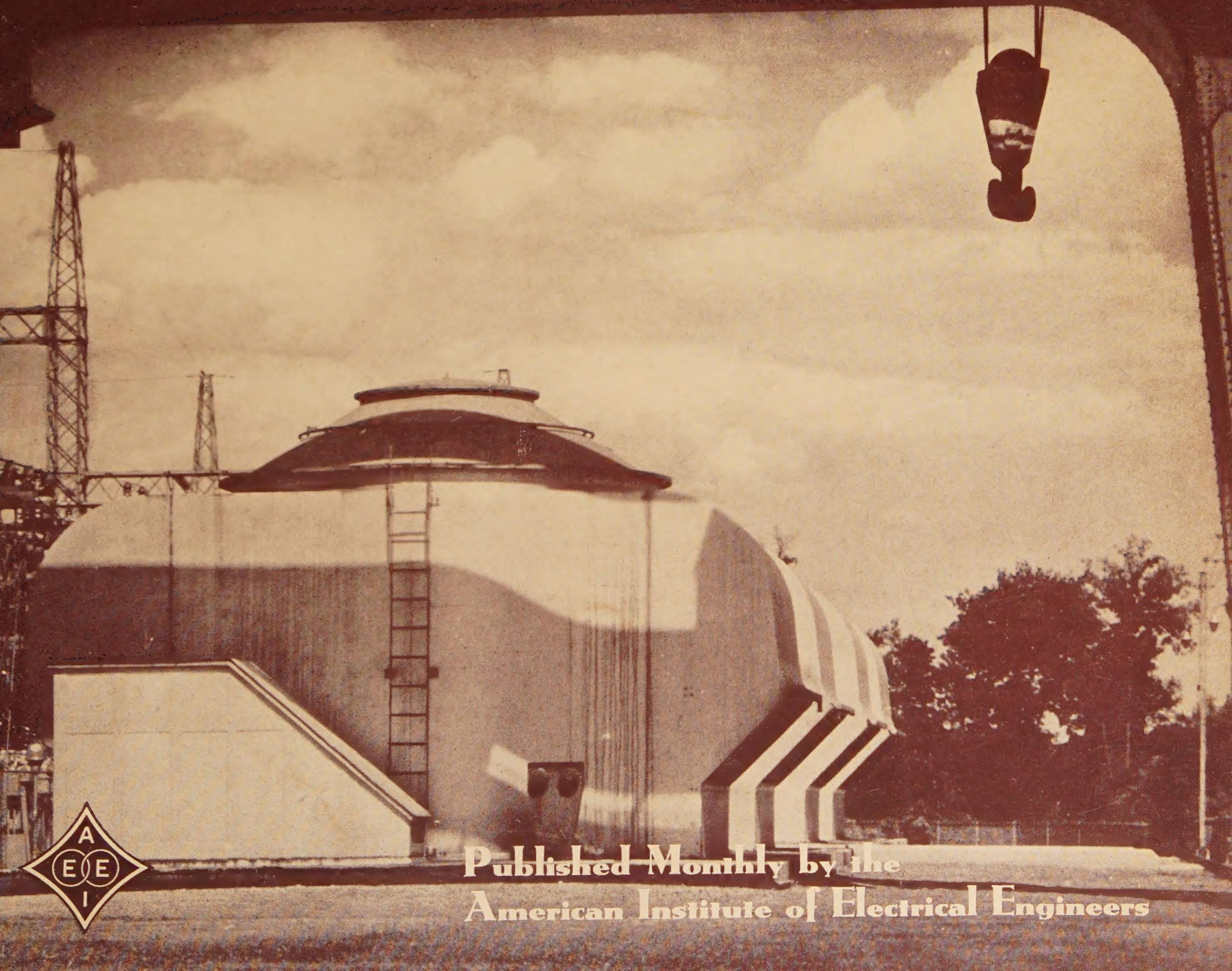

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High Lights • •

Air Circuit Breakers. An air circuit breaker of the 5,000-volt class has been developed which can be applied to circuits capable of producing short-circuit duties of 250,000 kva; this has been made possible through magnetically enhanced diffusion of ionized particles, establishing dielectric strength in a gaseous region which was previously highly conducting (*Transactions pages 197–201*). A 138-kv 1,500,000-kva air-blast circuit breaker recently developed features a new interrupting device utilizing an axial-blast nozzle together with a "conserved pressure" chamber, enabling the interruption of circuits of high voltage (*Transactions pages 193–7*). Application of the theory of interruption with compressed air to an interrupting element suitable for high-voltage work has been made also in connection with the experimental development of an outdoor circuit breaker for 138-kv service (*Transactions pages 217–22*).

Damping in Synchronous Machines. Relatively simple formulas for the calculation of the positive and negative damping torques of synchronous machines have been developed from a simple physical explanation of the phenomena. Using these formulas, the influence of the two axes of the machine upon the damping can be found (*Transactions pages 210–13*).

Designing Cable for Stability. Maximum power-factor stability of cable insulation under load-cycle conditions so far attained has been achieved by the combination of a new principle of cable structure and a newly developed impregnant having a marked degree of stability (*Transactions pages 206–10*).

Control in Interconnected Systems. To co-ordinate the operations of interconnected power systems of any size or geographical extent, automatic frequency controllers with time-error correction and tie-line controllers with frequency bias and time-error correction have been developed. The principle of frequency bias on a tie-line controller has been used extensively to permit maximum deviation from schedule load with minimum change in generation (*Transactions pages 232–6*).

Complacent Confusion. Since our democracy rests full-weight upon the proposition that the people are competent to determine their destiny, the consequences of confusion are not only personally but nationally disastrous, declares an eminent educator and engineer, who urges as a remedy for the prevalent state of complacent confusion that students learn to take the initiative in their own education (*pages 199–201*).

Magnetic Fields in Meters. As part of a general study of magnetic conditions existing in watt-hour meters during their operation, the effect of wave form on the registration of such meters has been studied under carefully controlled conditions (*Transactions pages 202–05*).

Network Master Relay. A three-phase single-element induction-cylinder network master relay which uses potential coils connected from line to line has been found to produce greater tripping torque during unbalanced primary feeder faults than did previous relays, which were three-phase, three-element devices with line-to-neutral potential coils (*Transactions pages 237–41*).

Protective Link. A protective device in transformers has been developed which disconnects any unit on which a breakdown or fault occurs internally, thereby reducing the shock to or outage on the feeder. The "protective link" consists of a fusible element within a fiber tube having one fixed and one movable electrode (*Transactions pages 226–9*).

Lamp Starter. Successful operation of hot-cathode fluorescent lamps is dependent upon a satisfactory starting device. The glow switch, a small simple, two-wire thermal relay operated by the heat from a glow discharge, performs automatically the necessary functions, and also is finding application in relay circuits (*Transactions pages 223–6*).

Directional Relay. An inductor-loop type of construction for high-speed polyphase directional relays, believed to offer decided advantages over other types, has been developed. Such a polyphase relay can be used for directional discrimination with high-speed impedance or overcurrent relays, and also for pilot-wire service or with carrier-current systems (*Transactions pages 246–8*).

Static Electricity. Lack of understanding of the generation of static electricity on rubber-tired vehicles has been responsible for the slow progress in development of effective precautionary measures against its hazards; analysis of the nature of the problem shows why existing methods of control are largely ineffectual (*pages 202–08*).

Resistance Welders. Factory wiring for resistance-welding machines has been considered in the third section of the report of the AIEE welding committee's subcommittee on power supply for welding operations, which shows how properly to lay out a plant distribution system for serving welders (*Transactions pages 185–92*).

Temperature Variations. Curves showing the variations of mean temperatures with altitude throughout the United States have been developed as an aid to the Institute's standardization activities (*Transactions pages 230–2*).

Measuring Cloud Heights. A "ceiling projector" is used to learn the height of the cloud ceiling over airports at night; a photoelectric device has been developed to extend its use to daytime hours (*pages 209–10*).

Electric Power in Aircraft. Because the makers of electrical equipment have taken little interest in the special problems of the aviation industry, other types of accessory power have been used for duties which electric power could easily perform; some of the problems and needs are presented for consideration (*pages 218–25*).

Small-Diameter Wires. Among significant features of the 1940 National Electrical Code are the recognition of small-diameter wires and permission to use these wires to fill a greater percentage of conduit area; these and other changes in the wiring tables have been analyzed (*pages 211–16*).

Switching Surge Voltages. Current-limiting fuses have been designed to provide inherent control of switching surge voltages with designated acceptable limits; these fuses employ conducting elements having two or more sections of different diameters (*Transactions pages 214–17*).

Ultrahigh-Speed Reclosures. Conclusions regarding ultrahigh-speed reclosing of high-voltage transmission lines have been developed on the basis of data covering five years' operating experience with 33 installations of high-speed reclosing equipment (*Transactions pages 241–6*).

Coming Soon. Among special articles and technical papers currently in preparation for early publication are: a symposium on fluorescent lighting by O. P. Cleaver (A'36), Preston Millar (M'13), A. B. O'Day, and Arthur A. Brainerd; an article describing the calculation of fault currents in industrial plants by R. C. R. Schulze; a report on apparatus bushings by the AIEE joint committee on bushings; a paper on bushing and associated insulation testing by the power-factor method by C. C. Baltzly (M'23) and E. L. Schlottere; a paper on high-voltage bushings designed to meet modern service by T. F. Brandt (M'37) and H. L. Rorden (M'36); a paper on enclosed busbar electrical distribution systems for industrial plants by E. T. Carlson (A'35); a paper outlining a construction theorem for evaluating operational expressions having a finite number of different roots by P. C. Cromwell (A'28); a paper reporting a study of sound-levels of transformers by H. Fahnoe (A'35); a paper on an electrolytic process of scale removal from steel by H. W. Neblett (M'21); a paper on the suppression of magnetic vibration and noise of two-pole turbine generators by A. L. Penniman, Jr. (M'32) and H. D. Taylor (M'34); a paper on arc-backs in ignitrons in series by J. Slepian (F'27) and W. E. Pakala (A'38); a paper reporting experience with preventive lightning protection on transmission lines by S. K. Waldorf (M'36); a paper on the detection of initial failure in high-voltage insulation by J. B. Whitehead (F'12) and M. R. Shaw, Jr. (A'40); a paper on lead storage batteries in the transportation field by Roland Whitehurst (M'21); and a paper dealing with surges on Chicago 12-kv system by F. O. Wollaston (A'27) and H. J. Plumley (A'39).

Complacency in Confusion

ROBERT E. DOHERTY
FELLOW AIEE

Because it contains so much food for thought for all students, whether in college or out, this address, originally delivered to a student group at the institution of which Doctor Doherty is president, is presented here for the benefit of all "students" in the AIEE audience

MOST PEOPLE live in a state of complacent confusion. College students and graduates are no exceptions. How many of them, for instance, have only a vague and confused notion of the fundamental principles of their professional study or practice; how many of them are content to live without a clearly thought-out philosophy of life; how many of them are inclined to think with their emotions instead of with their minds; how many, disillusioned by events of the past decade, are intellectually lost and assume the role of the cynic; how many, I ask, thus bear their own evidence of confusion? I believe you will agree with me that the number is discouragingly great.

The consequences of complacent confusion are serious. If these consequences were personal only—if they were merely the unrewarded personal careers, or the travail of minds that see no way out of new and trying situations, or the sterile satisfactions that go with intellectual poverty—they would be serious enough. But the consequences do not end there. They become national in scope when confused minds decide matters of destiny, for our democracy rests full-weight upon the proposition that the people are competent to determine their destiny. If they depend upon leadership, as they must, and leadership is confused, the consequences in national and local community life must be devastating, and indeed they have been devastating. By leadership I do not mean Federal leadership alone. It is only a part of the whole. I mean every policy-making body or policy-making person in the country, whether in business, industry, education, or government. The general direction of flow of national and community life depends upon the general policy pattern constituted of all the individual policies of these agencies, and the people must accept that flow of life. Hence the consequences of confusion may strike you on two serious counts. They may strike you personally and professionally if you elect to join the large ranks of the confused, and then you may continue to be the victims with all the rest of us of confused leadership.

You thus have a definite and direct personal interest in this matter, and also a very important interest as a citizen, even if this may appear to you less direct. My purpose here is to help you to recognize your interest and to encourage you to do something about it. I realize that the immediate, direct personal interest is, from your point of view, probably a more convincing basis for my appeal to you, but since the general social interest is not less important to you, I wish to pursue it further.

In the confused and demoralized world in which we now live, and which certainly will become more confused and more demoralized, there is a great challenge to the college students of America. It is the challenge to become intellectually prepared to deal with such a world, to meet with intelligence, courage, and confidence the new and trying situations which rapid changes are now bringing about. In such a world, which will be the world of your generation, life in America must be profoundly affected. National life will be difficult. Individual life will be difficult. The formulas of day-to-day contemporary life will not suffice because many of them will not apply to the new situations. New formulas must be thought out, and in this thinking there must be a return to the very fundamentals of science and living. There must be a clarification of basic philosophies—personal, professional, social. There must be clear, straight thinking. And to have these there must be genuinely educated people. Walking encyclopedias and handbooks will accomplish little. College graduates who have learned only the routine skills and formulas of their work will be intellectually lost in a world of new problems and thus will be ineffective in determining either social or individual destiny. There must be an intellectual renaissance, and that is your challenge.

I have mentioned confusion and its consequences and how I find these related to your own interests. I wish now to consider the question why in a nation of incomparably great educational opportunity there should be such pervasive confusion; why it is that the experience of 16 or 18 years of formal study, especially the period of college study, does not cultivate in more students a deeper understanding and a greater intellectual competence? After I have considered this question, I shall indicate more fully the nature of the task you will face if you set out in earnest to cultivate your own mind to its full capacity.

An address delivered to students at the Carnegie Institute of Technology, Pittsburgh, Pa., on "Carnegie Day," November 26, 1940.

Robert E. Doherty is president of Carnegie Institute of Technology, Pittsburgh, Pa.

Does the habit of confusion and superficiality among so many college graduates stem from an inherent lack of intellectual capacity? Many times I have heard this given as the reason. But my personal experience with students and large numbers of young graduates does not confirm this defeatist view. Now I know it is a long hard struggle for most of us really to learn the art of constructive thought, but I know too that many of us have more capacity for understanding and for intelligent thought than we are given credit for having. In college we may be slow in getting our thinking gears into mesh; and if while we are trying to get them into mesh the external machinery of classroom procedure moves too fast, the gears get stripped. Then disorder and confusion result. However, with a little more patience and a little more emphasis at the right points, more of us might have got our mental machinery into gear and successfully made the shifts until we got into high gear. No, I do not accept the view that inherent limitations of mind fix the intellectual achievements of college graduates at their present levels. We all have our own limits, of course, and these are not the same for everybody; but I am convinced that there is still good leeway between actual and potential intellectual achievement. So we must look elsewhere for the trouble.

I have already hinted at it. We strip the gears. The trouble is that too much is undertaken in the time available. In the modern curriculum there is so much subject matter to be covered that in the time available few, if any, students can cover all of it with understanding. The result is that they do not understand much of what they have covered, or only partly understand it. They come to depending more and more upon memorizing, and less and less upon understanding. This process of racing through, with one eye on the next quiz, pages of words and formulas with half understanding or no understanding is utterly demoralizing. It is repeated in American colleges day after day, month after month, year after year, until superficiality becomes a habit, until confusion becomes accepted as a normal state of mind. With such a habit firmly established in college, it naturally persists afterward; and thus confusion and superficiality mark the minds of too many graduates.

It is therefore a deplorable fact that the college diploma is usually not a certificate of a cultivated mind. Rather it may signify only that the graduate has acquired the requisite number of credits by meeting the course requirements of grades, lessons, and attendance. And the meeting of these requirements is no guarantee of intellectual competence in the sense that I am stressing. The work may have been fully done and good grades received, and still the diploma might not be a certificate of a cultivated mind. I mean a mind that can cope with new situations—a mind that intelligently can find its way out of perplexities, whether these be professional, personal, or social—and that has the capacity of humane appreciation. The test for identifying a cultivated mind is to face it with perplexities—to face it with new situations not in the books but involving principles and knowledge which that mind has studied. Then see how it behaves. Does it grab for straws, does it become emotional, is it evasive, does it give up? Or does it try to anchor to principle, does it have a philosophical base for its thought, has it essential knowledge, however limited, that will give meaning to its principles and to its philosophy, and can it think logically in applying all of these to the understanding and solution of the new situations with which it is faced? I might state the point in still different words. An educated person is one whose intellect has been cultivated in the processes of understanding, of thinking, of appreciating, of solving perplexities; and the only way yet found that I know of to cultivate these processes is actually to engage in them, to experience them, and to keep on experiencing them at increasing levels of difficulty. Thus, the question whether at commencement you, and indeed all other college graduates, will have achieved the status of educated persons will not, I am afraid, be answered completely by the fact that you and they have received diplomas. Moreover, neither will the extent to which you have approached that status be necessarily measured by the number of courses you have taken, nor yet infallibly indicated by our grades. But you can measure it. You can tell whether you understand thoroughly what you have studied, whether you have grasped great truths and worked them into your thinking so that as time goes by you can think your way out of situations and problems of increasing difficulty. You can know your own mind. Do not rest upon the assumption that a college diploma tells the whole story. It does signify that you have completed a college program and it may also be a ticket to a job; but it is not a ticket to the ranks of intellectual competence or to a successful career.

I am trying to have you grasp what I consider to be the most important thought in your educational career. It is this: that genuine education—the only kind of education that will help you to advance professionally and that will help you to live a life of service and satisfaction in a changing world—is not to be achieved merely by memorizing large quantities of miscellaneous information; it is not to be achieved merely by learning formulas, important as many of these may be; still less is it to be achieved by memorizing the words or the symbolisms of such information without understanding what they mean. It is to be achieved only by the acquisition of fundamental knowledge that is thoroughly understood and by the development of a purposeful attitude of mind and of a competence in thinking your way out of perplexities.

I realize I am on delicate ground. I run the danger of suffering your judgment that I indulge in pedantic counsel to you, and the faculty's judgment that my appraisal may be too pessimistic. I hope that I may not deserve such judgments; but if I seem to, may I ask that before the judgment becomes final, you at least think over carefully what I say and place it against the background of the world changes you see on all sides.

In any case, do not misunderstand me. Memorized information and formulas are of course important, indeed they are essential, but only so if they are thoroughly understood and furthermore are related *in your own mind* to a definite intellectual purpose. Then they cease to be miscellaneous information and become knowledge. For instance, it is futile to learn, however perfectly, the language

of Newton's laws of motion unless the significance of the language is clearly comprehended in its relation to the tangible physical facts which these laws correlate; in other words, unless one can visualize and interpret a physical situation involving these laws.

Let me be more specific regarding the nature of genuine education as I conceive it. I will discuss four essential elements which I have already mentioned in passing. The first is the acquisition of fundamental knowledge; that is to say, the learning and understanding of great basic truths and of a sufficient background of related fact to give definite and constructive meaning to those truths. As great truths I include those in the physical world, in the social and economic world, and in the realm of the human spirit. There are not many. I refer to such principles as the law of conservation of energy; the law of diminishing return, the principle underlying the golden rule. There are of course hundreds, perhaps thousands, of principles and formulas derived from such basic truths, much as the numerous theorems of geometry are derived from a few fundamental premises; and then there are perhaps a few hundred more based upon somebody's opinion. But it would be both hopeless and futile to undertake to learn all of them. One must discriminate between these and the great truths that form the bedrock of intelligent thought.

A second element is the development of a philosophy of life. This is a long process. It is settling upon basic purposes and attitudes in life and the reasons for them; it is placing the indispensable underpinnings of faith and courage and self-confidence. It is a continuing building process—the process of testing against the experience of your own life and the recorded lives of others, those purposes and attitudes that are tentatively adopted and of thus selecting and fitting in, piece by piece, the structural units of a life purpose. For instance, one important and immediate unit in this structure with which you are now presumably concerned is professional purpose. I do not mean the specific details and place of your future work, but the broad lines of professional activity that now seem to offer the greatest promise of those satisfactions which, after careful thought, you have come to cherish.

Next I mention humane appreciation. A mind or life that shuts itself off from an understanding of man as a human being; that shuts itself off from an appreciation of the desires and disappointments, the yearnings and satisfactions that motivate human activity; that shuts itself off from an appreciation of the literature and arts through which the human soul has attempted to express itself—such an isolated mind or life is only half human, and therefore not genuinely educated.

Finally I come to intellectual competence. Without this competence the other elements I have mentioned—fundamental knowledge, a philosophy of life, and humane appreciation—would represent merely passive satisfactions. Such satisfactions are of course important fruits of education. But they do not constitute a whole; they are complementary to another fruit—the fruit of constructive thought. And to achieve this competence in thinking one's way out of perplexing situations is to round out that genuine education which I am urging upon you.

Do you want that kind of an education? Do you wish to prepare for keen competition? Do you wish to preserve your precious liberty of thought, speech, and worship?

If you want these things you can have them, provided you pay the price. I doubt that the price is any higher than you are now paying, for I know most of you are already working hard. But it is a different kind of price. It is the price of *taking the initiative* in your educational work. This demands of you greater resolution than does merely *following* the regimen of classwork. It requires greater devotion to purpose.

No one can possibly do this educational *job* for you. The assumption that the instructor can do it for you is the basis for more educational confusion than any other I can think of, save one, namely, the assumption that education is achieved by memorizing a lesson merely in order to report it back on a quiz and get a grade. A recent definition, if I may be facetious, is that education is the process by which the instructor's notes get into the notes of the student without passing through the brains of either. No, the kind of education I am proposing cannot be given to you; you must *win* it by hard intellectual struggle in which you take the initiative. The faculty may inspire you to intellectual effort, but you must exert it; the faculty can help you to understand, but you have to do the understanding; the faculty can coach you in the art of logical thought, but you must do the thinking; and the faculty can help you to cultivate good taste and humane appreciation, but you have to do the cultivating. Every time you struggle with a new concept and *master it*—for instance, a physical law, or an economic theory, or a concept of art—you will have made an educational advance, you will have added to your intellectual stature. Furthermore, every time you make *use* of such a law or theory or concept to think your way out of a perplexity or to experience a new appreciation, you will have achieved another and further intellectual advance. But in both cases you must do the job. You, not the coach, must carry the ball.

So I urge you to take the initiative and learn to use your heads. In the first place, dig yourself out of confusion. Insist on understanding! Do away with superficiality! Stop memorizing words and formulas that you do not understand, merely for a grade. Do not go on cultivating a habit that will cripple your mind for the rest of your days—the habit of superficiality, the habit of accepting confusion as a normal state of mind, the habit of playing on words that carry no meaning. You know when you understand and when you do not; when you grasp a point that is clear and clean cut and when, instead, it is blurred and confused. With all the emphasis in me I repeat: Insist on understanding! Then, under the guidance of the faculty in your regular class programs, but under your own initiative, you will be in position to go forward more effectively and more rapidly with the acquisition of great truths, the evolution of a philosophy of life, the cultivation of humane appreciation, and the development of intellectual competence—in other words, a genuine education gauged to the demands of the changing world in which you will live.

Static Electricity on Rubber-Tired Vehicles

ROBIN BEACH
FELLOW AIEE

Although the public is becoming increasingly conscious of the fire and explosion hazards presented by static electricity, development of precautionary measures has been seriously impeded by lack of understanding of the nature of the problem. This study of the fundamental elements of static electricity on rubber-tired vehicles is intended to provide a basis for developing methods of control.

STATIC electricity received scant attention from the layman until the use of radio receivers became widespread a few years ago. Although atmospheric and man-made interference with radio communications produced many difficult and interesting problems for the radio engineer, it was, and still is, just a nuisance to the general run of broadcast listeners.

The public, however, is more static-conscious today than ever before. This is due, no doubt, to the frequent, almost daily press reports of disastrous fires and explosions attributed to discharges of static electricity, in grain elevators, oil refineries, munition plants, paint factories, and other industrial operations. News items of explosions "caused by static" in motion-picture projection booths, hospital operating rooms, domestic kitchens, and gas-filled basements of school houses vividly emphasize and bring home the subject of static electricity to the newspaper reader.

Rapid and extensive developments in industrial processes and equipment, coupled with the fact that so little really is known about the generation of static electricity and the vagaries of its behavior, seem to account for the alarming increase in the number of industrial fires and explosions presumably and probably caused by it.

The voltages which result from rapidly moving belts, conveyors, paper stock, fabrics, and similar materials, as well as those which originate at nozzles from rapidly issuing steam and other gases, attain amazingly high values under favorable conditions. It is not generally known that charges of electricity are produced under conditions of violent turbulence and high velocity, when liquids, such as petroleum and its fractions—gasoline, naphtha, kerosene, and others, are pumped through pipe lines, and that the accumulation of these charges at the terminal tanks under certain conditions can cause high voltages to be developed.

In these various ways, voltages ranging from a few thousand up to as high as 75,000 volts have been recorded, in some cases with large quantities of stored charge ready to arc to ground.

Surprising as it may seem, one can generate a stored charge in his body at a voltage as high as 10,000 volts by scuffing over a woolen rug on a dry, cold day and, upon discharge, cause a spark of sufficient intensity to light a cigarette lighter or a gas jet. Even this commonly known phenomenon can be potentially dangerous. Recent newspaper accounts described the ignition of vapors from anesthetics being administered to patients on the operating table, causing the patients' deaths. The vapors were ignited by the discharge of body charges of the surgeons generated by their scuffing about on the rubber floor mats during the operation.

From a humane point of view alone, tragic accidents of this sort call for a widespread and concentrated study of the generation, behavior, and control of static electricity. The wasteful costs of litigations arising from such accidents and the losses occasioned by the destruction or damage of properties constitute an economic and engineering problem of importance.

HAZARDS OF STATIC ELECTRICITY ON RUBBER-TIRED VEHICLES

A great many fires and explosions are known to have originated from the sparks resulting from high-voltage discharges on gasoline trucks, oil trucks, and carriers of explosives and of other inflammable materials. Fires have occurred at bulk plants and distributing stations of the gasoline and petroleum companies, despite the employment of rather costly protective devices installed in the hope that such devices would discharge all traces of static electricity. Static electricity is an ever-present menace to all industries which manufacture and transport inflammable and explosive commodities. Many people are surprised to learn that an empty gasoline truck, in which the residual vapors are thoroughly admixed with air, is no less of an explosion menace on highways than a load of dynamite. Even the static-electricity shocks from busses and automobiles should not be considered lightly, since, in cases of impaired health, they have been known to lead to serious consequences.

Since the use of rubber-tired vehicles for industrial carriers is being extended into many new fields, the fire and

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explosion hazards from static electricity are being multiplied. Too frequently precautionary measures which should be taken against these dangers are unknown to those employed in these industries. In fact, since practically no authentic information has been published on this subject of static electricity on rubber-tired vehicles, it is problematical where information and advice on the subject could be obtained.

The author was similarly confronted with this dearth of information about two years ago in connection with a court case in which a fire was believed to have been started by the discharge of static electricity from a storage tank that was being filled by a gasoline delivery truck. Since that time he has conducted many tests on pleasure vehicles, busses, trucks, and tank trucks, both on the highways and on the new Otis "proving stands," for the purpose of securing as complete information as possible on the subject.

THE VARIABLE FACTORS IN THE PROBLEM

These tests led into devious and lengthy studies in order to determine where and how the electric charges on the car bodies were generated, what their polarities and distributions were on the tires and on the car bodies, what the magnitudes of the voltages were between the car body and ground, how the characteristics of the roadways affected the problem of generation, how conditions of tire-loading, tractive effort, and temperature influenced the voltage, and how other such variables as humidity, seasons, types of roadways, and tire conditions entered into the general problem. The problem contains many variables, some of which do not lend themselves readily to control unless costly methods are employed. The results of these studies are recorded in this article.

The seat of the generation of electric charges that constitute the electrification of a rubber-tired vehicle is at the area of contact between the tires and the roadway. The process of electrification is identical with the well-known ones of charging ourselves by scuffing on a woolen rug, or of charging a vulcanite rod by rubbing it with a piece of fur. One of the substances acquires charges of positive electricity while the other gains an equal number of charges of negative electricity. Since rubbing is commonly associated with this method of electrifying substances, it is not difficult to understand how the misnomer "frictional electricity" was given to the process many years ago. Actually, friction plays no part in the fundamental nature of electrification of substances brought into intimate contact. The application of pressure or friction between the substances simply helps to establish more extensive and at the same time more intimate contact of one substance with the other. Really there is no such physical phenomenon as frictional electricity.

THE PRINCIPLE OF "CONTACT DIFFERENCE OF POTENTIAL"

This process of electrification is that known as "contact difference of potential". It is a most interesting phenomenon about which much yet remains to be learned. If two substances, say two metals, are placed tightly in contact, a redistribution of so-called "free" electrons takes place within them, and therefore a difference of potential is established across their boundary, which is the contact difference of potential. The substance which gains electrons becomes negatively charged and the other, having lost electrons, becomes positively charged. The boundaries of the metallic substances are normally bombarded by the free electrons in their attempt to escape, a condition that is similar to the boundary restraint imposed by surface tension against the escape of atoms of a fluid. The flow of the electrons between metals in contact occurs from that substance for which the lesser force acts at its boundary contacts to impede their escape.

These contact voltages for metals have been found to range from a few tenths of a volt to about one volt. The surfaces that are firmly in contact are actually separated by distances of the order of molecular proportions, approximating 1/100,000,000 inch or less. These orders of magnitudes are important, since, as we shall see, they determine the values of voltages found in static electrification. As the two metals are now separated, the stretching of the lines of force between the positive charges on one and the negative charges on the other causes the voltage between them to increase, thereby tending to reunite these separated charges. Being free to move through the conductive metal to the location of least potential difference, which occurs at the last point of remaining contact between the surfaces, the two metals upon separation thus completely lose their charges and hence all evidence of former contact voltage.

In nonconductors of electricity, with which we are concerned here, the electrons are unable to move about freely as in the metals. When a vulcanite rod, for example, is

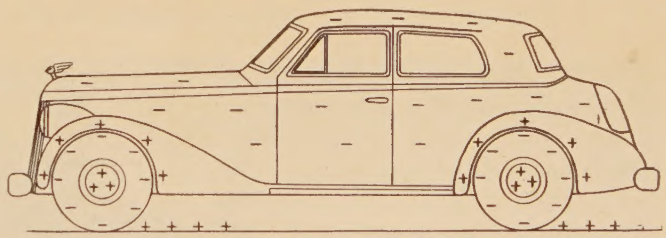


Figure 1. The normal distribution of charges on the body of an electrified vehicle, showing the "wake" of positive charges in the roadway

rubbed with fur, electrons are known to pass from the fur into the vulcanite at each point of contact and remain there fixed in position. The rubbing procedure merely serves to cause new areas to come into contact and to provide additional interchange of electrons, thereby multiplying the amount of electric charge acquired by each surface. The contact voltage is probably somewhat lower than for the metals, but when the separation of their surfaces is made one important difference distinguishes the nonconducting substances from the metals. Since the charges are constrained to remain in fixed positions for nonconducting materials, each substance retains about as many charges as were imparted to it by the contacts, and the difference of potential increases rapidly as the surfaces are separated and in inverse proportion as the capacitance decreases ($C=Q/E$), attaining values of many thousands of

volts. A similar condition is obtained by rubbing a metal with a nonconducting substance, provided the metal is insulated from ground so that it retains its charges.

CHARGING THE VEHICLE

Rubber tires are composed of organic materials which possess excellent insulating characteristics. This is also true of the materials which compose the modern highway, such as macadam, asphalt, concrete, or wood or granite blocks. As the wheels of the vehicles roll along these roadways, the tires acquire electrons and thereby become highly charged with negative electricity. The positive atomic charges lie as "wakes" behind the speeding wheels in the surface of the roadway, and they concern us no longer. However, the negative charges on the tires have a strong influence in electrifying the car body.

The high negative electrification on the tire treads repels to the more remote parts of the car body the free electrons in the metal of those parts that are in closest proximity to the tires, such as the wheels and fenders. This leaves high positive electrification on the adjacent metal parts as so-called "bound" charges; and the repelled electrons on the remainder of the metal parts of the car constitute what are known as "free" charges, because, if a path is provided for them, they will flow off to ground. Figure 1 shows the normal distribution of charges on a car body. This separation of the charges on the car body is the well-known process of "electric" induction. In other words, the charges induced on the metal parts adjacent to the negatively charged tire treads are positive ions because the free electrons are repelled, and these positive charges and the negative charges on the tires are bound by a strong electric field which exists between them—a condition which is measured by their potential difference or the voltage.

If the negative electrification on the tires is assumed to be removed by neutralizing the charges, the "free" charges would no longer be repelled, so they would flow back and neutralize the positive ions, or "bound" charges. The car body would then be again uncharged and no voltage would exist between it and ground. On the other hand, when the car was normally charged by induction from the electrified tires, suppose the "free" charge had been conducted to ground by momentarily connecting the car body to a hydrant, and suppose the negative charges were then neutralized on the tire treads, the positive ions which are fixed in their positions in the metal structure then would be the only charges on the car. They would strongly attract free electrons to neutralize them, thereby leaving positive ions distributed over the entire body. Since these positive charges cannot escape, the car still would have its previous value of potential above ground, only it now would be positive, whereas prior to discharging the "free" negative electrification, the potential was negative with respect to ground. These various conditions were measured and checked, both on road tests and on the Otis proving stand, by voltmeter, by microammeter, and by electroscope—the latter being a device by means of which the presence of a minute amount of charge and its polarity may be determined.

METHODS OF TEST

During the early stages of testing for voltages between car bodies and ground, readings were taken on cars as they came to a standstill at the toll booths at the Holland Tunnel in New York City, and at the Marine Parkway Bridge in Brooklyn. An electrostatic voltmeter was employed for these measurements which had various scales calibrated in volts up to 15,000. The ground terminal of the meter was connected to a grounded stanchion, and the high-potential terminal was connected to a wire which was attached to a contactor on a pole, like a fish pole, that could be touched to the bumpers of cars as they stopped for toll. Figure 2 shows such a view. These readings were taken largely during the summer months. Busses and trucks, and especially heavy gasoline trucks, gave the highest voltage readings, approximating 5,000 volts. As was found later, the voltages at these locations were affected greatly by the high

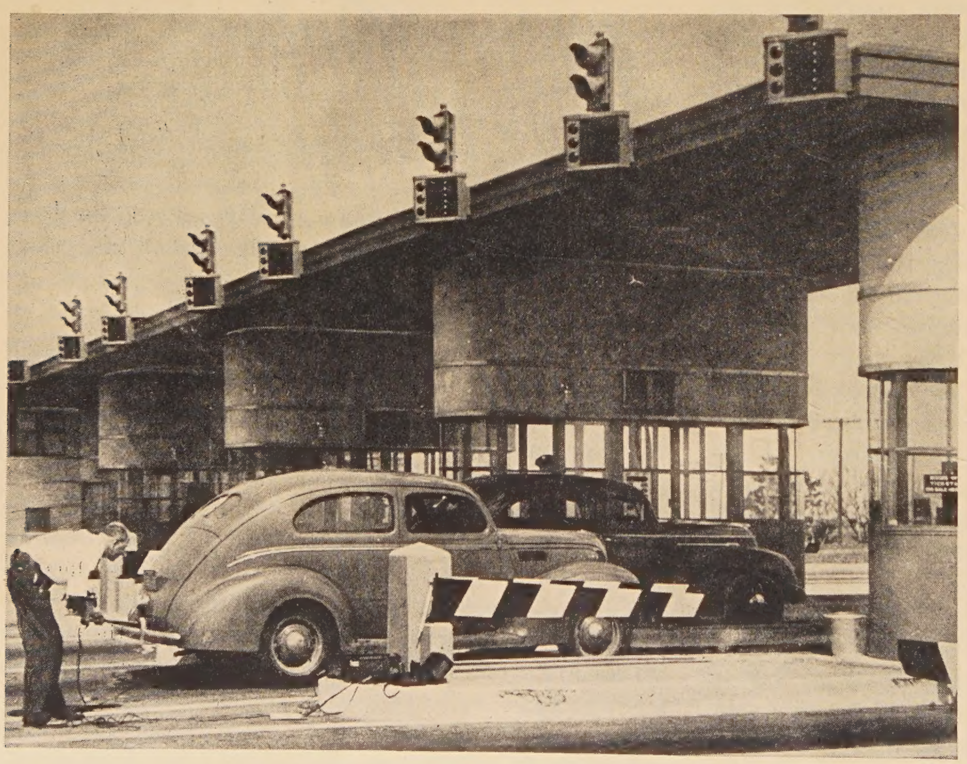


Figure 2. Cars undergoing the measurement of their electrostatic voltage at the Marine Parkway Bridge, Brooklyn, N. Y.

humidity of the summer season, by the direct exposure to salt atmosphere, by hot tires, by relatively low surface resistivity of the roadway, and by various other factors.

Later the author equipped his automobile as a traveling laboratory for tests on static electricity. A metal contactor was attached to, although insulated from, the front bumper, being located midway between the front wheels, so that it could be lowered to the pavement; and by means of an insulated wire this contactor could be connected to the ground terminal of the electrostatic voltmeter. The high-voltage terminal of the meter likewise could be connected to either of two insulated wires, one from the inner surface of a fender, and the other from the upper part of the car body. During the dry, cold weather, the meter indications were, for the most part, well off the 15,000-volt scale and subsequently a 30,000-volt scale was added to the meter. When the car was stopped at these times, the voltage was found to remain at its high value for the full duration of the stop of 20 minutes or more, sometimes with no apparent decrease, while at other times the indication would very gradually diminish, giving evidence that hours might be required for total discharge.

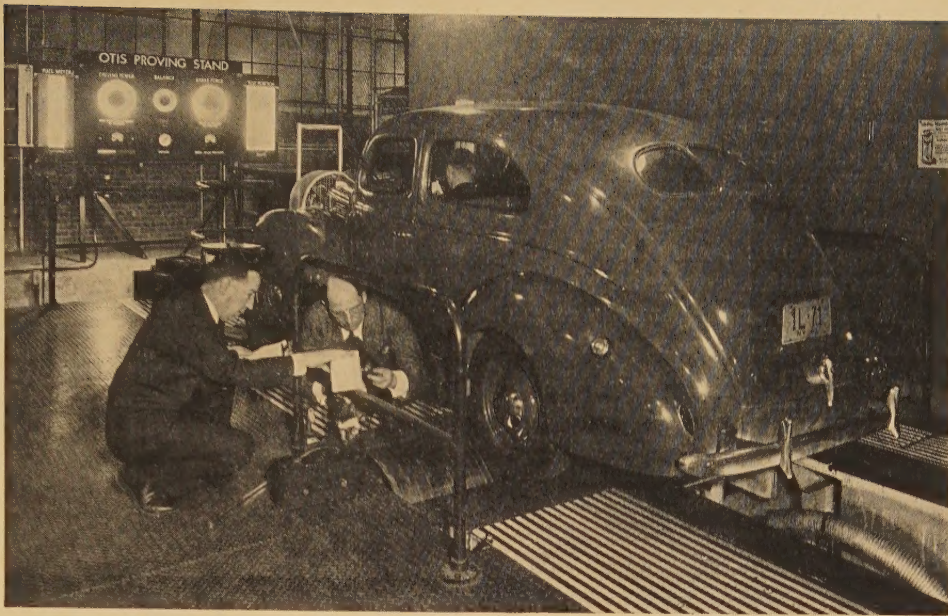


Figure 3. A Ford sedan being tested for electrostatic voltage on the Otis proving stand at the garage of the Brooklyn Edison Company

Under these conditions the use of the so-called "drag" chain, as frequently seen with two or three links dangling on the pavement at the rear of gasoline trucks, was found to make no measurable difference in the rate of decrease of the voltage on the car. For such tests, a set of two skid chains was attached to the bumpers so as to provide extensive contact with the roadway between the wheels. Since the pavement was not grounded but rather comprised a most excellent insulator, the "drag" chains, obviously, could not be expected to discharge the car. Surface resistivities of roadways, as measured by a 1,000 volt d-c megger, between two parallel metal strip electrodes, each 4 inches long, and separated about 1/4 inch, ranged between 1,500 megohms and values well beyond the 2,000-megohm meter scale. Also tests taken of the resistance through the pavement to the ground beneath indicated values of a similarly high order. This was equally true for asphalt and concrete roadways.

In order to control some of the variable factors which influenced the voltage generated by rubber-tired vehicles, many of the tests were conducted on various types of vehicles by means of a high-speed chassis dynamometer. The rear wheels of the car rest upon and drive large drums on this device, which can operate a generator for the purpose of applying any desired value of load to the car. In this way readings of the electrostatic voltage could be taken under any desired load from no-load to heavy loads and at speeds up to 70 miles per hour. Such variables as air currents, changes in humidity, and changing roadway conditions could be eliminated or controlled in these tests. The drums upon which the rear driving wheels operate were grounded, and the voltmeter was connected between any desired part of the car body and the ground. The dynamometer, and one of the many cars tested, together with the various apparatus, are shown in figure 3.

RESULTS OF DYNAMOMETER TESTS

The tests for the voltage which was developed between car body and ground were taken on cars by means of the dynamometer which was operated from speeds of zero to 60 miles per hour at no-load. This condition is equivalent to driving the cars along a level highway without even the resistance of windage. The voltage characteristics for a passenger car and for a five-ton dumper truck are shown in figure 4 as curves, which appear similar in form to the well-known magnetic saturation curve. The three curves for each vehicle are taken for three different pressures of tire inflation. The decreasing rate of voltage rise beyond the knee of the curves for the high speed values implies that a condition of electrification on the tires is approached where further inflow of electrons from the roadway surfaces is increasingly opposed by the intensity of the negative charge already present on the tire treads. This behavior is particularly noticeable for the curves of the lightweight passenger car.

The other voltage-speed curves that are shown in figure 5 for the same car with other values of tire inflation are similar in form, as may be seen, differing only in the magnitudes of the voltages. For the highest tire inflation of the passenger car, the tire loading was 34.5 pounds per square inch, and the voltage is seen to rise to higher values than for lower inflation. From the theory of contact po-

tential difference, this condition is to be expected. With the higher unit loading of the tires, the tire fabrics are forced down into more intimate contact with the microscopically rough and hilly surfaces of the drums in the case of the dynamometer or of the highway in general. For the normal inflation, as shown by the middle curve for the passenger car, the unit tire loading was found to be 31.7 pounds per square inch, and for the lowest inflation, the bottom curve, the loading was 29.1 pounds per square inch. Curves of similar form have been obtained on the highway for voltage versus speed, but the results are more difficult to obtain and are not, in general, as readily reproducible.

The curves for the five-ton truck show that the same general results were obtained as for the passenger car except that at no load the voltage of approximately 13 kilovolts was obtained for a speed of about 40 miles per hour rather than at 60 miles per hour as shown in figure 4 for the lightweight car. This significant fact indicates that much higher voltages would be generated by the truck at higher speeds before the curves reached their maximum values.

The same two vehicles were then given a series of load tests. One such test consists of loading the generator of the dynamometer, while the pounds of push, or tractive effort, at the treads of the rear wheels are increased in order to maintain a constant speed of drive. The effect of this loading on the generated voltage is observed to vary linearly with the tractive effort. These tests were taken at four different speeds for the passenger car and at three different speeds for the five-ton truck as indicated by the curves of figure 5. As the push increases at the treads of the rear tires, the rubber fabrics in tending to slip are forced closer into the interstices of the molecular surface structure of the drums, or roadway, with a resultant increase in the extent of the contacting surfaces and therefore in the proportionate voltage.

In the case of the truck, the slope of the curves of volts versus tractive effort is about 800 volts per 100 pounds of tractive effort, while for the passenger car, the slope is only 300 volts per 100 pounds of tractive effort. The measured values of tire loads for the truck and for the pleasure vehicle are, respectively, 119 pounds per square inch and 34.5 pounds per square inch. If the ratio of these two values of slope voltages is compared with the ratio of the two values of tire loads for the two vehicles, the two ratios are seen to have remarkably close agreement.

This porportionality of voltage to tire loading is in accord likewise with the principle of "contact difference of potential". As explained before, the greater the tire loading, the greater the extent of the surfaces that are pressed into contact, and therefore the greater the voltage. For these and other reasons, it is believed that voltage values ranging between 30,000 and 40,000 volts may be generated on the highways by busses and trucks at high-speed operation.

Additional interesting information was obtained from a number of tests made on a high-speed chassis dynamometer employing drums composed of compressed paper. Since these drums were excellent insulators, rather than conductors, as were the grounded metal drums of the Otis

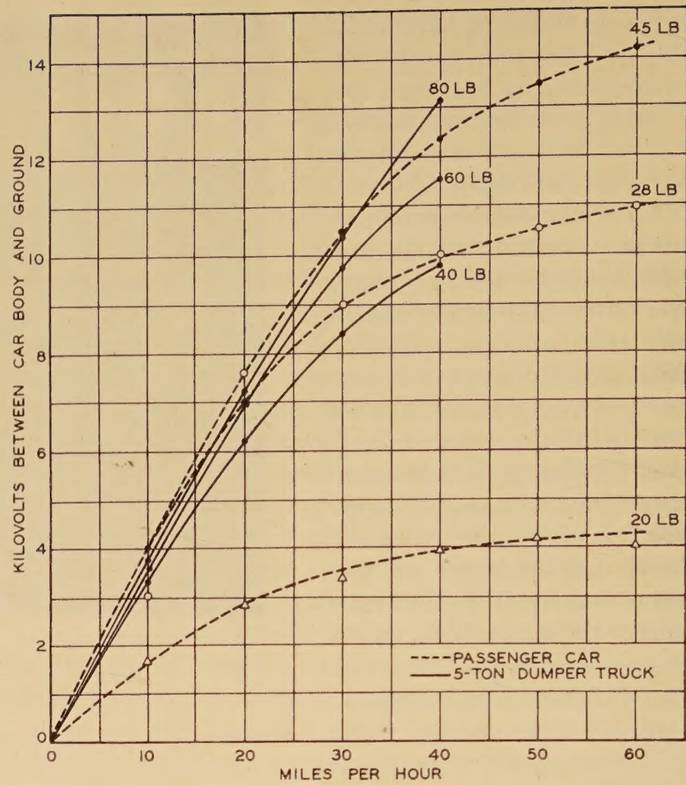


Figure 4. A family of voltage "saturation" curves for the Ford car shown in figure 3 and for a five-ton dumper truck

proving stand, the electric charges that were generated on the paper drums during operation remained on their surfaces. Because of this they neutralized in part the negative charges on the tire treads. The voltages in this case would not be expected to rise to as high values as formerly, and were found not to do so. Steel wire brooms, in which the bristles had been grounded, were then placed upon the surfaces of the drums, so as to permit the positive charges to be neutralized, as rapidly as they were generated, by electrons from the ground. As soon as this was done, the voltage increased to about double its former value.

These tests also clearly demonstrated the effect of increasing temperature on lowering the generated voltage. Since the paper drums are likewise excellent heat insulators, the temperature of the tires increased appreciably with the duration of the voltage-speed tests. The voltage for a no-load test, at first, increased for speeds up to 30 miles per hour, after which it then decreased as the speed was increased up to 60 miles per hour, falling off about 20 per cent from its maximum value. The temperature was approximately 80 degrees Fahrenheit, or about summer heat, whereas the ambient temperature was 63 degrees Fahrenheit. In a subsequent test, when a temperature of about 124 degrees Fahrenheit was attained on the side walls of the tires, the voltage continuously decreased, under no-load and constant speed, from 6,600 volts, by one minute intervals, to 5,600 and then to 3,200. Apparently, from special studies directed to this phase of the electrostatic-voltage generation, the contact difference of potential is lowered as the temperature of the tires is increased. Tires do become warm during operation in the summer months, but in the winter season, in

the cool or cold climates, they run cool. They are cooled in part by natural windage but largely by the cold new areas of roadway with which they are continually coming in contact.

EXPERIENCES ON ROAD TESTS

On many occasions the voltage of the car body was found to decrease as the car slowed down on the highway and to become zero when it stopped. This condition was observed to be coincidental with that of the car body being of negative polarity throughout rather than positive nearest to the tire treads and then negative elsewhere on the body, as was shown in figure 1. These related facts led to the inference that the roadway surface was slightly conductive as the result of a moisture film caused, perhaps, by a certain meteorological condition. Not only did this permit the negative charges on the tire treads to be neutralized as the car stopped, but the tire walls became sufficiently conductive when the car was running to charge the car body by conduction rather than by induction, and of course, when it stopped, the car readily discharged by the same process. This demonstrates, as has been proved otherwise, that the degree of dryness of the roadway is the all-important factor in determining how long the electrification will remain on the car body.

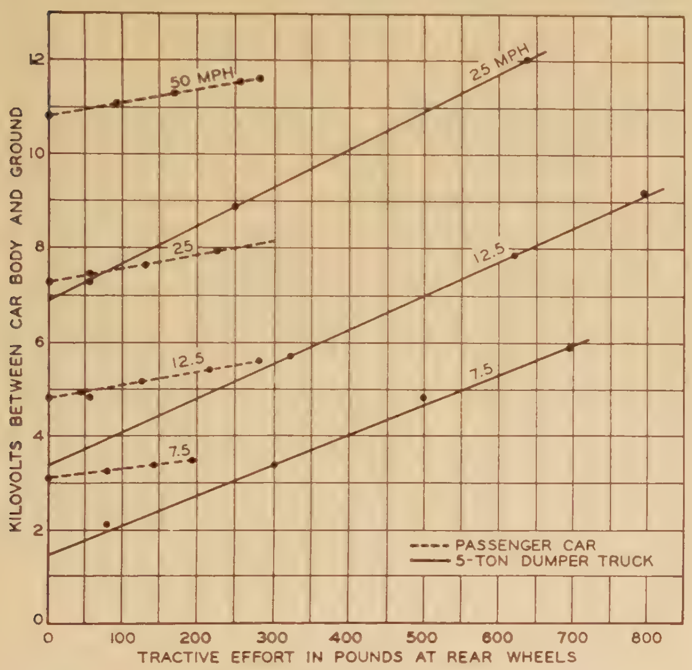


Figure 5. Voltage-load curves for the Ford car and five-ton truck, simulating the condition of ascending steeper and steeper grades at constant speed

Discharge tests taken on edges and points of metal of the sharpness of those found on the parts of the car body show that, at the higher voltages, brush discharge causes some lowering of the voltage. This discharge occurs across the side walls of the tires between the positive and negative areas of electrification, as well as from the other parts of the body into the air. This means that a continuous generation of charges must occur, if the voltage is to be maintained at high values.

HAZARDS FROM SHOCKS

Measurements have been taken of the capacitance of pleasure cars with respect to ground, wherein the metal of the car body is considered as one plate of the capacitor and the earth the other, with the dielectric or insulation between as a complex composite of the intervening air, and the rubber tires. These values range from 500 to 650 micro microfarads. For large trucks, busses, and large tank trucks, the capacitance ranges between 950 and 1,500 micro microfarads, and for the body capacitance of people its average value is about 120.

Assume a truck, having a capacitance of 1,000 micro microfarads and charged to a voltage of 20,000 volts, to be touched by a person whose resistance from fingers through his shoes to ground is 20,000 ohms. The current through his body then is limited at the instant of contact by his resistance to a value of 1 ampere, which value reduces to 1/3 ampere in about 20 microseconds, and it becomes about zero in 60 microseconds, after which the truck, as a capacitor, then becomes practically discharged. However, a current of 1 ampere might be dangerous even though of very short duration, and might prove fatal if it should pass through the heart. Very little is known of the physiological effects of current of short duration through the body. Under certain conceivable conditions this resistance might be as low as 2,000 ohms, and the current at the moment of contact could be as large as 10 amperes.

Fortunately, people are normally well insulated from ground by their shoes, which, when dry and soled with rubber, may have insulation resistance as high as 100 megohms. In this case a person who touches an electrified vehicle becomes charged from it just as any capacitor might be charged by conduction from another. Assuming the same numerical values as given for the truck, and that the person touching it has a capacitance value of about 100 micro microfarads and a contact resistance of 3,000 ohms, the first inrush of current would be over 6 amperes, but it would decrease to practically nil in about 1 microsecond. Perhaps in this case only an unpleasant shock would be obtained with the customary tingling effect. Frequently such experiences are passed off in good nature, although strong and robust mechanics are known to have been thrown violently to the ground as a result of severe shocks received from the static electrification of trucks.

PROBLEMS OF CONTROL OF STATIC ELECTRIFICATION ON VEHICLES

Consider again the case in which the body of the vehicle has been discharged of its "free" negative electricity by grounding it, as was previously explained. The tires still retain their high charge of negative electricity and the high positive electrification is still held "bound" at the wheels and fenders. This condition of "discharge" may have been attained through the grounding of the vehicle, say a tank truck, by means of the grounding grids that are sometimes used at the distributing or bulk stations of gasoline companies. Yet the potential hazards of sparks still remain. Any conducting object that is allowed to touch the tire and the fender may produce the necessary spark to ini-

tiate a fire or explosion. Quite likely many of the "mysterious" fires in and about these bulk stations have been started in just this way. Nor does one such discharge terminate the difference of potential at these locations. Since the rubber of the tire is an insulator, only those negative charges on the tire where the conducting object touches are neutralized by an equal number of positive charges on the fender. The resulting spark may be feeble in many instances, but in others a strong, vigorous spark may result. Demonstrations simulating these conditions have established the validity of these conclusions, and they have proved how ineffectual the elaborate grounding grids at the distributing stations of the oil companies may be as safeguards against the fire hazards of static electricity.

With the body of the vehicle discharged of the "free" electrification by grounding it, as previously explained, a sense of false security from the latent dangers of static electricity all too often results. To see how hazards of sparks still may exist despite the elaborate practices of grounding, assume that the grounding connection has been removed. If now the negative electricity on the tires becomes neutralized or discharged in any manner, the previously "bound" positive electrification at the wheels and fenders is released, and it then distributes itself over the surface of the body identically as did the "free" negative charges just prior to the grounding procedure. Now the full force of the fire and explosion hazards of the static electricity is again present, although the truck body was duly grounded and the normal negative electrification of the body discharged. Such are the "lurking" dangers that hover about as menaces to safety, and unless these hazards are recognized and preventive procedures established to dissipate their latent energies, continued loss of life and property is the inevitable consequence.

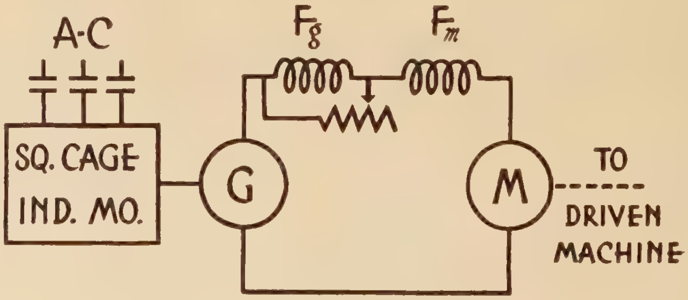
Progress in solving these problems of static electricity on rubber-tired vehicles has been retarded throughout the years by lack of recognition of the basic elements of the problem. Many "crackpot" and costly attempts to solve the problem without any knowledge of the offending elements have led to the uses in varying degrees of "drag" chains, or of rubber ribbons surfaced with conducting coatings attached to the under chassis of busses and trucks, or of tires painted with conductive coatings of graphite or aluminum, or even of tires marked with pencil lines. In fact, tires have been placed on the market that are made of so-called conductive rubber—that is, of rubber whose normally high resistivity has been considerably lowered by the addition of "loading" ingredients possessing conductive qualities.

None of these attempted methods of solution recognizes the element of generation of the electrification, where it occurs, or particularly how the charges are stored on the body of the vehicle. If the tires were highly conductive, say even of metallic composition, as long as the roadway continues to be an excellent insulator the generation of high electrification is fundamentally unchanged. Obviously, too, if the roadway possessed high resistivity, the charges on the tires could not readily flow away, and therefore they would remain on the body of the vehicle, possibly for hours. The charges in the case of conductive tires would not be induced on the body of the vehicle as shown in figure 1. Instead, the negative charges would flow, by conduction, to the wheels and thence to the other metal parts of the body, and the difference of potential between the body and the ground would be determined by the amount of charge generated at the tire treads, much as it is in the case of the normal type of rubber tires.

The author hopes that his efforts to present the fundamental elements of static electricity on rubber-tired vehicles in these studies will be rewarded by their giving encouragement to others to attack various phases of the problem. Perhaps methods of reducing the generation of charge at the tire treads may be devised. This would strike at the very heart of the problem. A study of simple means for discharging the static electricity as it is generated offers an attractive field for investigation. Basically the civil engineer has an interest, if not a definite responsibility, in the problem, since the laying of modern highways which possess these high resistivities is a product of his conception. Perhaps he can solve the problem in some manner by devising a conductive road surfacing.

A Simplified Adjustable-Speed Drive

THE high-torque characteristics of a d-c series motor are combined with a flat speed characteristic similar to that of a shunt machine in a newly developed a-c adjustable-speed drive recently announced by the Westinghouse Electric and Manufacturing Company. The drive has a continuously variable speed range of ten to one and consequently is more flexible than adjustable-speed units employing wound-rotor motors. As may be noted from the accompanying diagram, the drive includes three machines: a squirrel-cage induction motor driving a series d-c generator which is directly connected to a d-c series driving motor. Speed adjustments are made by varying the resistance connected in parallel with the generator



series field. This type of drive is applicable to a wide variety of industrial power applications requiring from 1 to 15 horsepower. As line-start induction motors are used, the set is started and stopped by means of push-button control. As the output of the self-excited generator builds up gradually under normal starting conditions, the driving motor is "cushioned" against mechanical shock.

Daytime Photoelectric Measurement of Cloud Heights

MAURICE K. LAUFER   LAURENCE W. FOSKETT

Information on the height of the cloud ceiling, vitally important to airplane pilots, now may be obtained during the day as well as at night. The use of the "ceiling projector" has been extended to daytime measurements by means of a photoelectric detector developed by the National Bureau of Standards for the United States Weather Bureau.

THE height of the cloud ceiling and information concerning the rate at which it is rising or falling above an airport are of particular interest to the pilot who is scheduled to land at that airport within an hour or so. In the United States and Canada, the meteorological services use "ceiling projectors" at airports to determine the height of ceilings at night. The intense beam of light from such a projector forms a conspicuous spot on the base of the cloud. A simple optical instrument at some known distance from the projector is used to measure the angle between the line of sight on the spot and the line of sight on the projector. The tangent of the angle of elevation of the spot, multiplied by the base-line distance from the optical instrument to the projector, gives the height of the ceiling when the base line is horizontal and the projected beam is vertical.

Several years ago, W. E. Knowles Middleton of the Canadian Meteorological Service initiated the first work on a photoelectric detector that would extend the use of the ceiling projector to the daytime measurement of cloud heights through the utilization of a modulated beam. Modulating a projected beam so that, after scattering, the light retains its original "identification tag" was suggested in 1935 by Tuve[1] as a possible means of studying the upper atmosphere. The United States Weather Bureau requested the National Bureau of Standards to develop the necessary equipment for measuring ceiling heights in this way during the daytime.

MEASURING EQUIPMENT

Figure 1 shows schematically the arrangement of the equipment developed. The projector consists of a 24-inch parabolic mirror equipped with an a-c-operated high-intensity *A-H6* mercury-vapor lamp. The modulation of the beam is approximately 95 per cent[2] and has a frequency of 120 cycles per second when the lamp is operated on 60-cycle current. A photoelectric tube and 8-inch lens are used to detect the modulated light signal after reflection from the cloud ceiling. The signal is amplified by a five-stage 120-cycle resistance-capacitance tuned amplifier. In practice the detector scans the base of the cloud until the output meter indicates that the light signal is being received. The angular setting of the detector then corresponds to the angular elevation of the spot on the cloud.

EFFECT OF BACKGROUND BRIGHTNESS

The method described would seem to make it possible to sort out completely the modulated light signal from the background light of the cloud, but the "shot noise" of the photoelectric tube resulting from the background light limits the detection. The shot noise is caused by the fact that photoelectrons are emitted at random, even when the illumination is constant. The analogous "shot effect" in thermionic emission is well known. Thus the photoelectric-tube current produced by a constant background light may be considered as consisting of a steady component equal to the average current with a random varying current superimposed. This varying current produces across the photoelectric-tube load resistor a varying potential that is amplified in the same way as the modulated signal and may obliterate the signal.

Statistical theory shows that the rms value of the varying current is proportional to the square root of the average current and the resulting amplified noise is proportional to the square root of the effective band width of the amplifier. In order to keep the average photoelectric-tube current produced by the background at a minimum, the optical system of the detector was designed to pick up an area on the ceiling no larger than the spot illuminated by the projector. A diaphragm was located at the focus of

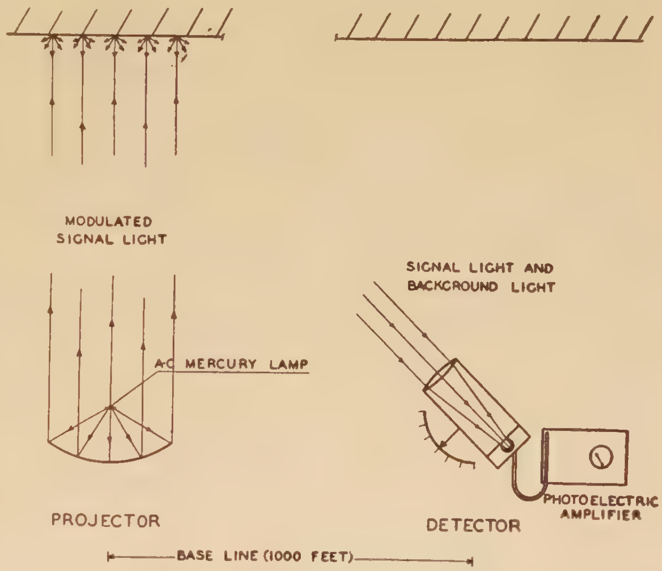


Figure 1. Schematic diagram of equipment used to measure the height of cloud ceilings

Based on a paper presented at the ninth annual meeting of the Institute of Aeronautical Sciences, January 29–31, 1941, New York, N. Y.

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the 8-inch glass lens, and an RCA 929 photoelectric tube was placed immediately behind the diaphragm. The 929 photoelectric tube was chosen because its response is high in the spectral region where the mercury lamp emits most of the energy usable in a glass system. With this setup, photoelectric-tube currents as large as 25 microamperes have been obtained when the detector is directed at clouds illuminated by direct sunlight. Such a current is more than 10^6 times the signal current obtained for moderately high ceilings.

Johnson[3,4] has shown that, if the band width of the amplifier is sufficiently narrow, the limit of detection of an a-c signal in the presence of a random background noise depends only on the period of the output meter. The amplifier used has an effective band width of 100 cycles, which is narrow enough to make the minimum detectable signal dependent only on the period of the output meter if the background noise results from statistical causes; that is, if the background brightness of the clouds is constant. But during the time the scanning is made to find the spot, the background brightness will be varying, and, moreover, there may be large changes in brightness from cloud to cloud. The resulting variations in background noises may cause a change in the output current many times that produced by the signal when the spot is located, making it quite impossible at times to locate the spot.

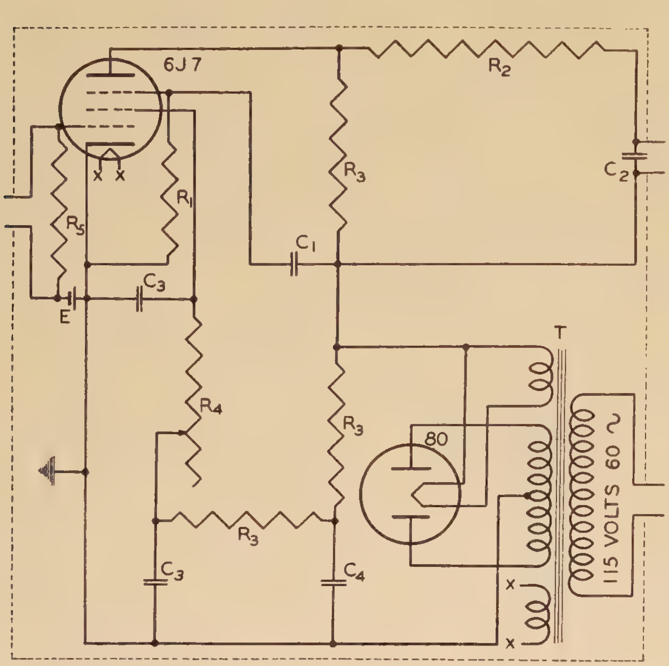

Figure 2. Wiring diagram of output circuit having the following circuit constants:

Microfarads		*Megohms*	
C_1	0.0001	R_1	20
C_2	4	R_2	3
C_3	40	R_3	0.1
C_4	4	R_4	0.1
		R_5	0.5

T 830 volts, center-tapped
E 1.25 volts grid bias cell

If, however, a 120-cycle synchronous commutator, which is phased with the signal, is introduced between the amplifier and the meter, the average output current in the absence of the signal will be zero, because of the random phase of the amplified noise. Thus the variations in brightness of the clouds will not give a false indication of the signal, since the same average zero reading will be obtained for the noise whether the average photoelectric-tube current is 25 microamperes or 2 microamperes. A second advantage results because effectively an increased scale length can be used for the output meter. Normally the noise would produce an average reading 10 to 100 or even 1,000 times that resulting from the signal, but if the average noise-output current is reduced to zero, the entire scale of the meter can be used for indicating the signal.

OUTPUT CIRCUIT

An "electronic switching-circuit", which performs the same function as a synchronous commutator, is shown in figure 2. The rectified but nonfiltered output of the transformer is the plate supply for the 6*J*7 tube. If the resistance R_4 is correctly adjusted, the plate current consists of square-topped pulses which are maintained for approximately 1/240 second. The time average of the *IR* drop across the plate resistor R_3 can be obtained from the potential across the capacitor C_2. This potential is reasonably steady because of the long period of the series circuit consisting of R_2 and C_2. Furthermore, the magnitude of this potential is almost completely independent of the amplified noise from the amplifier because of the random phase, as in the case of a synchronous commutator. When a sustained and phased 120-cycle signal is added, the potential across C_2 increases or decreases, depending on whether the positive or negative portion of the signal is present during the time the plate current is flowing. A vacuum-tube voltmeter is used to indicate the change in the potential across C_2.

RESULTS

During the daytime, dark overcast clouds at an elevation of 9,000 feet have been detected readily with the equipment described. For cumulus clouds illuminated by direct sunlight and having elevations up to 4,000 feet, the detection is positive.

In order to determine the minimum signal which can be detected with certainty in the presence of a background light, battery-operated incandescent lamps were used to produce the background light. A signal light about 5×10^{-7} times the background light was detected; this is less than twice the theoretical minimum.

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New Building Wires Recognized by 1940 Code

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MEMBER AIEE

The significance to plant engineers of the small-diameter and other new types of building wires, and the changes in temperature limits and current-carrying capacities, recognized by the 1940 edition of the National Electrical Code

THE 1940 edition of the National Electrical Code recognizes 19 different types of building wire. Only 7 of these are rubber-covered building wires, yet when an electrical engineer thinks of building wire he almost instinctively calls to mind rubber-covered wire. This is because rubber insulation has been so generally satisfactory that it is produced and used in a volume vastly in excess of all the other types of wires combined. Within its temperature and voltage limits it has no peer. Most of this article therefore will be devoted to rubber-covered wires, although other types will be mentioned briefly.

The various types of insulated wire with their type letters, are listed in table I, with a brief description of the insulation, the outer covering, and the recognized use. Type *R* is the old familiar code-grade rubber which has been recognized in the Code for over 30 years. In fact, recently some of this wire was removed during remodeling of the Chicago testing station of Underwriters' Laboratories, Inc., after it had been in use for 35 years, and under test was found still to have good dielectric and physical properties. Its temperature limit is 50 degrees centigrade, however, and that limitation forms the basis for much of the change that has taken place and for a tremendous amount of development work on the part of the wire industry.

Type *RW* wire is very similar to type *R* except that it is compounded so as to have more resistance to moisture, a most desirable feature where continuously exposed to moisture as in underground runs. This wire has been recognized in the Code for only a few years and therefore does not have the background of experience of type *R*, although some manufacturers have been making a similar product as a specialty with much success over a period of years.

Type *RP* is a performance-grade rubber, specially compounded to have a higher resistance to heat than code rubber, and is recognized up to an operating temperature of 60 degrees centigrade, which, as table II shows, has a decided bearing on its current-carrying capacity.

Wire of *RH*, or heat-resistant, type has even greater resistance to heat and is recognized for continuous operation at 75 degrees centigrade. This type represents the highest development to date in rubber-covered building wire.

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Type *RHT* is merely a small-diameter type *RH*, the *T* standing for a thinner insulation. This material has exactly the same limitations, temperature and otherwise, as type *RH*.

Type *RPT* is a thin-wall type *RP* insulated wire and is separated in table II from type *RP* because it is used only for rewiring in existing raceways, whereas all the materials previously mentioned are for general use. Type *RU* is a rubber-insulated wire of very small diameter on account of the thinness of the rubber insulation. It is made by a special process and contains 90 per cent pure rubber. It has an excellent record to date in the limited applications where it has been permitted. The temperature limit on this unmilled grainless rubber is 60 degrees centigrade. It is limited likewise to the rewiring of existing raceways.

Type *SN* is a wire with a so-called synthetic insulation, meaning presumably that it is man-made from totally different materials. *SN* wire is limited to 60 degrees centigrade and to use in existing raceways, but is made in larger sizes than are the other materials for rewiring. This material differs from the others in several respects. For one thing, there is no necessity for an outer fibrous covering, because of the toughness of the insulation and the relatively inert character of the synthetic material which does not need protection from the light as rubber insulation does. It is, however, slightly subject to cold flow under pressure and tends to be brittle at temperatures below freezing.

The question is frequently raised as to why these special wires of small diameter are limited to rewiring use. The answer, I believe, lies in the desire of the electrical committee of the National Fire Protection Association to proceed slowly with the recognition of new products and give them an opportunity to prove their worth under limited conditions of use before extending recognition for general use. I believe there was a desire also to provide some leeway for future expansion of facilities in a building having concealed raceways that can be changed only at prohibitive expense. If the loading of the circuits increases later as it has in the past, a little space would remain for pulling in additional wires under limited circumstances, if all the available space had not been utilized originally.

Type *SNA* is a combination of synthetic insulation and asbestos. It is a switchboard wiring material of little interest from a building-wire standpoint.

Type *V* is the old familiar varnished-cambric wire that has been used for many years. Its new operating tem-

Table I. Conductor Insulations—600 Volts

(1940 National Electrical Code)

Trade Name	Type Letter	Maximum Operating Temperature	Insulation	Thickness of Insulation	Outer Covering	Use
Code	R	50C (122F)	Code-grade rubber	14–10 .... 3/64 in. 8–2 .... 4/64 in. 1–4/0 .... 5/64 in. 250–500 ...... 6/64 in. 501–1,000 .... 7/64 in. Over 1,000 .... 8/64 in.	Moisture-resistant flame-retardant fibrous covering	General use
Moisture-resistant	RW	50C (122F)	Moisture-resistant rubber	Same as Type R	Moisture-resistant flame-retardant fibrous covering	General use or in wet locations. See section 3055
Performance	RP	60C (140F)	Performance-grade rubber	Same as Type R	Moisture-resistant flame-retardant fibrous covering	General use
Heat-resistant	RH	75C (167F)	Heat-resistant grade rubber	Same as Type R	Moisture-resistant flame-retardant fibrous covering	General use
Small diameter building wire (heat-resistant)	RHT	75C (167F)	Heat-resistant grade rubber	14–10 .... 2/64 in. 8 .... 3/64 in.	Moisture-resistant flame-retardant fibrous covering	General use. See 3005-d
Small diameter building wire (performance)	RPT	60C (140F)	Performance-grade rubber	14–10 .... 2/64 in.	Moisture-resistant flame-retardant fibrous covering	Rewiring existing raceways. See 3005-e
Type RU wire (See note)	RU	60C (140F)	90 per cent unmilled grainless rubber	14–10 .... 18 mils	Moisture-resistant flame-restardant fibrous covering	Rewiring existing raceways. See 3005-e
Solid synthetic (See note)	SN	60C (140F)	Solid flame-retardant moisture-resistant synthetic compound	14–10 .... 2/64 in. 8 .... 3/64 in. 6–2 .... 4/64 in. 1–4/0 .... 5/64 in.	None	Rewiring existing raceways. See 3005-e
Asbestos synthetic	SNA	90C (194F)	Synthetic and felted asbestos	14–8 Synthetic ..... 20 mils Asbestos ..... 20 mils	Cotton braid thickness, 20 mils	Switchboard wiring
Varnished cambric	V	85C (185F)	Varnished cambric	Same as Type R except 8 .... 3/64 in.	Fibrous covering or lead sheath	Dry locations only. Unless lead sheathed. Smaller than No. 6 by special permission
Asbestos varnished cambric	AVA	110C (230F)	Impregnated asbestos and varnished cambric	See table	Asbestos braid	General use dry locations
Asbestos varnished cambric	AVB	90C (194F)	Same as Type AVA	See table	Flame-retardant cotton braid	General use dry locations
Asbestos varnished cambric	AVL	110C (230F)	Same as Type AVA	See table	Lead sheath	General use wet locations
Asbestos	A	200C (392F)	Felted asbestos	14–8 .... 40 mils 6–2 .... 60 mils 1–4/0 .... 90 mils 250–1,000 .... 120 mils	With or without asbestos braid	Dry locations only. Not for general conduit installation. In raceways, only as leads to or within apparatus. If without braid or moisture-resistant treatment, limited to 300 volts
Impregnated asbestos	AI	125C (257F)	Impregnated felted asbestos	Same as Type A	With or without impregnated asbestos braid	
Paper		85C (185F)	Paper		Lead sheath	As permitted by 2304-b, or by special permission
Slow burning	SB	90C (194F)	3 braids impregnated fire-retardant thread	Same as Type V	Outer cover finished smooth and hard	For use only in dry locations where the room temperature exceeds 85C (185F)
Slow burning weatherproof	SBW	90C (194F)	2 layers impregnated cotton thread	Same as Type V	Outer fire-retardant coating	For use only in dry locations where the room temperature exceeds 85C (185F)
Weatherproof	WP	80C (176F)	At least three cotton braids impregnated	14–12 .... 3/64 in. 10–2 .... 4/64 in. 1–4/0 .... 5/64 in. 225–500 ...... 6/64 in. 525–950 ...... 7/74 in. 1,000 and over 8/64 in.		May be used for interior wiring only by special permission

perature of 85 degrees centigrade is a recognition of advancement in the type of varnish used, since the previous maximum was 75 degrees centigrade.

Types *AVA*, *AVB*, and *AVL* are combinations of asbestos and varnished cambric, with an asbestos outer braid and a temperature limit of 110 degrees centigrade for the first, a cotton outer braid and a limitation of 90 degrees centigrade on account of this cotton for the second, and a leaded jacket for use in wet locations for the *AVL*.

Types *A* and *AI* are asbestos-insulated wires having a heat-resistant impregnation in one case and a moisture-resistant impregnation in the other and temperature

limits of 200 and 125 degrees centigrade respectively, in recognition of the difference in these impregnating materials. This is the first effort of the asbestos-wire manufacturers to differentiate among their materials in the National Electrical Code. Heretofore type *A* has covered a multitude of types. It still covers several general types which should and probably will have individual designations.

Types *SB*, *SBW*, and *WP* are specialty wires for limited use. Probably plant engineers are likely to be interested in these wires only where they are run on insulators, a practice still common in mill buildings in some sections of the United States.

A paper-insulated cable also is recognized, but has very limited application under the Code, being primarily an underground-duct type of cable for use by electric utilities.

Three features of the changed wiring tables in the 1940 Code are of particular interest, in my estimation. One is the setting of a definite room temperature of 30 degrees centigrade, 86 degrees Fahrenheit, as a basis of calculation. Another is the difference in current-carrying capacities of the different types of insulation. The third is the recognition of a small-diameter wire and correspondingly the permission to use this small-diameter wire to advantage by having it fill a greater percentage of the conduit area.

In previous editions of the Code, the temperature limit of 49 degrees centigrade for rubber-covered wires and cables was an ambient air temperature without reference to the basic room temperature. This frequently caused confusion. The adoption of an average temperature of 30 degrees centigrade for the basic room temperature therefore represents definite progress and serves as a guide to installation inspection authorities throughout the United States. It is well known that this temperature will be exceeded in many localities for periods of several hours, but in only a few will a 24-hour average be in excess of 30 degrees centigrade. In those localities the higher temperature must be taken into consideration and the current-carrying capacity of the wires reduced accordingly. In special locations also, such as boiler rooms, where the temperature is consistently above 30 degrees centigrade, a correction factor must be applied.

Some inspection authorities, even in the North, are concerned about the temperature in attics, because it is above the assumed basis of 30 degrees centigrade. When it is considered, however, that the high temperatures in attics are for relatively few hours' duration, and only during the summer months, and that the highest temperatures seldom coincide with the heaviest demand for power, it is my belief that little concern need be felt about such locations. A similar situation exists in factories and should be treated in a similar manner. In every consideration of rubber-covered wire, it must be realized that a considerable factor of safety is built into the wires and high temperatures can be withstood for appreciable periods of time without serious injury, even though every such exposure tends to hasten the deterioration of the rubber. Even with considerable depreciation of the rubber, the insulation retains its dielectric strength unless the wire is moved to an extent that causes cracking of the rubber.

Table II. Allowable Current-Carrying Capacities of Conductors in Amperes

For Not More Than Three Conductors in Raceway or Cable Based on Room Temperature of 30 Degrees Centigrade or 86 Degrees Fahrenheit

(1940 National Electrical Code)

Size AWG or MCM	Rubber Type RW Type R	Synthetic Type SN; Type RU; Rubber Type RPT Type RP	Rubber Type RHT Type RH	Paper; Synthetic Type SNA; Asbestos Var-Cam Type AVB; Var-Cam Type V	Asbestos Var-Cam Type AVA	Impregnated Asbestos Type AI	Asbestos Type A
14	15	18	22	23	28	29	32
12	20	23	27	29	36	38	42
10	25	31	37	38	47	49	54
8	35	41	49	50	60	63	71
6	45	54	65	68	80	85	95
5	52	63	75	78	94	99	110
4	60	72	86	88	107	114	122
3	69	83	99	104	121	131	145
2	80	96	115	118	137	147	163
1	91	110	131	138	161	172	188
0	105	127	151	157	190	202	223
00	120	145	173	184	217	230	249
000	138	166	199	209	243	265	284
0000	160	193	230	237	275	308	340
250	177	213	255	272	315	334	372
300	198	238	285	299	347	380	415
350	216	260	311	325	392	419	462
400	233	281	336	361	418	450	488
500	265	319	382	404	468	498	554
600	293	353	422	453	525	543	612
700	320	385	461	488	562	598	668
750	330	398	475	502	582	621	690
800	340	410	490	514	600	641	720
900	360	434	519	556			
1,000	377	455	543	583	681	730	811
1,250	409	493	589	643			
1,500	434	522	625	698	784		
1,750	451	544	650	733			
2,000	463	558	666	774	839		

Correction factor for room temperatures over 30 degrees centigrade

C.	F.	Type RW Type R	Type RPT Type RP	Type RHT Type RH	Type V	Type AVA	Type AI	Type A
40	104	0 71	0.82	0.88	0.90	0.94	0.95	
45	113	0.50	0.71	0.82				
50	122	0.00	0.58	0.75	0.80	0.87	0.89	
55	131		0.41	0.67				
60	140		0.00	0.58	0.67	0.79	0.83	0.97
70	158			0.35	0.52	0.71	0.76	0.93
75	167			0.00				
80	176				0.30	0.61	0.69	0.89
90	194					0.50	0.61	0.86
100	212						0.51	0.82
120	248							0.72
140	284							0.63

NOTE: If the raceway contains from four to six conductors, the values in the table are reduced to 80 per cent. If the raceway contains from seven to nine conductors, the values in the table are reduced to 70 per cent.

The changes in current-carrying capacities of conductors as indicated in table II (table I of the Code) have caused some misunderstanding and no little criticism. Nevertheless these changes were necessary if the Code is to be kept in line with the engineering information available, as of course it must be.

In January 1938, S. J. Rosch, of the Anaconda Wire and Cable Company, in a paper delivered before the AIEE winter convention [*AIEE Trans., '38 (March), p. 155–67*] gave the basis for the current-carrying-capacity tables that now have been incorporated in the Code in modified form. The comparison in table III of the 1937 Code and the 1940 Code shows how extensive these changes in current-carrying capacity have been. In the larger sizes the changes would be alarming if it were not that practice over a period of years has tended toward lower

	Type R	Type SN	Type RHT

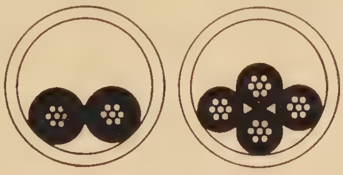
½-Inch Conduit

	Type R	Type SN	Type RHT
Watts	2,800	5,800	6,080
Wires	4 #14	8 #14	6 #14
Number of Circuits	2	4	3
Amperes Per Conductor	12	12.6	17.6
Circuit Length (Feet) for One Per Cent Voltage Drop	17.0	15.6	10.6

1-Inch Conduit

	Type R	Type SN	Type RHT
Watts	6,400	13,200	15,800
Wires	4 #8	8 #8	8 #8
Number of Circuits	2	4	4
Amperes Per Conductor	28	29	34.4
Circuit Length (Feet) for One Per Cent Voltage Drop	29.3	24.0	22.0

1½-Inch Conduit



Watts	12,100	23,400
Wires	2 1/0	4 1/0
Number of Circuits	1	2
Amperes Per Conductor	105	101.6
Circuit Length (Feet) for One Per Cent Voltage Drop	50.0	50.0

Typical examples of increased circuit capacity made possible by rewiring with the small-diameter building wire

All computations based on two-wire 115-volt circuits

values than those theoretically permissible according to the Code. This means that engineers doing layout work were aware that if cables were loaded to the full capacity permitted by the Code, overheating and unsatisfactory operation generally would result. The changes, therefore, are more theoretical than actual where a good engineering job was done, but will require more changes in those installations where the job was done by rule of thumb and where voltage drop was not the dominant factor, as in most instances it is and should be.

The problem of voltage drop is not covered in detail in the Code, although mention is made of the fact that the tables are based on temperature alone and do not take voltage drop into consideration. Nevertheless, if the minimum sizes of wire given in the Code are used, the voltage drop is so great that I believe this factor actually more important than the temperature of the wires under full load in determining the size of wire that should be used.

In section 2202 of the Code the statement is made that the size of feeders should be such that the voltage drop up to the final distribution point for the load will be not more than one per cent for lighting loads or combined lighting and power loads and three per cent for power loads. In view of that statement, tables V and VI were prepared to show the allowable circuit length for different sizes of wire and conduit where a maximum of one per cent drop is contemplated. The circuit lengths are exceedingly small. While theoretically greater values of current could be utilized by using rubbers permitting higher temperatures, practically, a larger size of wire has to be used on account of voltage drop regardless of the type of rubber. Therefore, for small sizes of wire, the highest temperature insulation and the different current values based on it will have little significance. High-temperature rubber does, however, give a greater range to rubber-covered wire and permits its use in locations where, for reasons of temperature alone, another and in some respects less suitable type of wire has had to be substituted in the past.

In the larger sizes, the change in permissible current is much more significant because voltage drop is not so important a factor. Comparison of the current-carrying capacities in the 1937 and the 1940 Codes as given in table III shows that the current-carrying capacity of Code-grade wire has been reduced radically. The 1937 current-carrying capacities for type *R* compare favorably with the 1940 current-carrying capacities for heat-resistant grade of insulation (*RH*). This probably will result in the use of the higher grades of insulation for the larger cables. As pointed out, rubber-covered wire in the larger sizes has not been used to any great extent to carry the full-load current for which it formerly was rated, so the change will mean that the values now given in the Code actually can be followed because they are scientifically based.

There has been a great deal of discussion on this phase of the change in the current-carrying capacity tables, particularly from those who have installed cables for others

Table III. Comparison of Current-Carrying Capacities of the 1937 Code and the 1940 Code

Current-Carrying Capacities in Amperes; Conductors in Raceways (1940 National Electrical Code)

Size AWG or MCM	Type R 1937 Code	Type R 1940 Code	Type RH 1940 Code
14	15	15	22
12	20	20	27
10	25	25	37
8	35	35	49
6	50	45	65
4	70	60	86
2	90	80	115
1	100	91	131
0	125	105	151
00	150	120	173
000	175	138	199
0,000	225	160	230
250	250	177	255
300	275	198	285
350	300	216	311
400	325	233	336
500	400	265	382
600	450	293	422
700	500	320	461
750	525	330	475
800	550	340	490
900	600	360	519
1,000	650	377	543
1,250	750	409	589
1,500	850	434	625
1,750	950	451	650
2,000	1,050	463	666

Table IV. Per Cent Area of Conduit or Tubing

(1940 National Electrical Code)

	Number of Conductors				
	1	2	3	4	Over 4
Conductors (not lead covered)	53	31	43	40	40
Lead-covered conductors	55	30	40	38	35
For rewiring existing raceways with conductors of thinner insulation, as provided in 3005-d and e	60	40	50	50	50

rather than for their own use. For plant engineers making installations for their own use, the change is highly desirable and results in bringing the provisions of the National Electrical Code into conformity with the latest engineering information.

The other significant change in the recognition of wires is the small-diameter building wire. This was sponsored by the electrical utility companies, which frequently were confronted with the difficult situation of a building wired with concealed conduit, the conduit filled to capacity on the basis of the old Code, and a greater number of circuits desired by the tenant or building owner. To pull out the old conduit and install new would be exceedingly expensive. They therefore have desired to use smaller-diameter wires having a higher grade of insulation that would give suitable performance despite the thinner insulation.

The Code therefore recognized small diameter wires in higher grades of insulation, such as the performance grade *RP*, the heat-resistant grade *RH*, the 90 per cent unmilled grainless rubber *RU*, and the synthetic insulation *SN*.

Table V. Circuit Length of Type R Wire in Feet to Give One Per Cent Drop

115-Volt Star, Source of Voltage Supply; Single-Cable Conductors, One-Phase Basis; Unity Power Factor

AWG or MCM	Allowable Current*	Circuit Length (Feet)	Number of Wires in Conduit	Size of Conduit (Inches)
14	15	17.3	4	1/2
		20.2	7	3/4
		20.2	9	1
12	20	16.4	3	1/2
		20.7	5	3/4
		23.6	8	1
10	25	25.9	4	3/4
		25.9	6	1
8	35	23.6	2	3/4
		29.3	4	1
6	45	28.2	2	1
5	52	29.9	2	1 1/4
4	60	32.2	2	1 1/4
3	69	36.2	2	1 1/4
2	80	39.2	2	1 1/4
1	91	43.2	2	1 1/2
0	105	44.9	2	1 1/2
00	120	51.2	2	2
000	138	55.8	2	2
0,000	160	60.0	2	2
250	177	63.9	2	2 1/2
300	198	67.4	2	2 1/2
350	216	72	2	2 1/2
400	233	76.5	2	3
500	265	80.5	2	3

*Maximum three conductors in raceway.

For three per cent voltage drop, multiply circuit length by three.

In conjunction with this recognition, the percentage area of conduit-fill also was increased, permitting a greater number of wires for a given size of conduit and to some extent making possible the increased number of circuits desired. Here again the voltage drop plays a decisive part. Tables V and VI indicate that if the circuits were loaded to capacity, the length of cable that could be used without exceeding the one per cent drop recommended by the Code for lighting circuits would be so small as to be impracticable.

Probably the real situation is that a large number of circuits loaded only partially to capacity are desired, and therefore the smaller diameter wires are an asset primarily

Table VI. Circuit Length of Type RH Wire in Feet to Give One Per Cent Drop

115 Volt Star, Source of Voltage Supply; Single-Cable Conductors; One-Phase Basis; Unity Power Factor

AWG or MCM	Allowable Current*	Circuit Length (Feet)	Number of Wires in Conduit	Size of Conduit (Inches)
14	22	12.1	4	1/2
		13.2	7	3/4
		13.2	9	1
12	27	11.5	3	1/2
		15	5	3/4
		17.3	8	1
10	37	17.3	4	3/4
		17.3	6	1
8	49	15.5	2	3/4
		20.5	4	1
6	65	19	2	1
5	75	20.2	2	1 1/4
4	86	21.8	2	1 1/4
3	99	23.6	2	1 1/4
2	115	26.4	2	1 1/4
1	131	28.2	2	1 1/2
0	151	30.5	2	1 1/2
00	173	32.8	2	2
000	199	36.2	2	2
0,000	230	39.1	2	2
250	255	40.8	2	2 1/2
300	285	43.1	2	2 1/2
350	311	45.5	2	2 1/2
400	336	48.9	2	3
500	382	51.8	2	3

*Maximum three conductors in raceway.

For three per cent voltage drop, multiply circuit length by three.

because of their physical dimensions, and not on account of their higher current-carrying capacity. The higher current-carrying capacity is, in this particular case, a by-product of the higher grade of insulation necessary to permit the use of a smaller amount of insulation.

Only in those places where a very short run of cable will be suitable can the full current values permitted for the higher grades of insulation be utilized without having excessive voltage drop.

The significance of the foregoing to plant engineers, is that rubber-covered wires now have a wider range with respect to temperature than those previously recognized in the Code. For some specific applications a larger number of wires can be run into old conduits and a much greater number of circuits obtained, although, on account of definite limitations in voltage drop, the full value of current theoretically permitted by the tables cannot be utilized.

Another way of looking at this is that with a number of small branch circuits loaded to capacity, where the voltage drop is now a serious factor, more copper can be placed in the same conduit under the rewiring rules and the same load carried with a much lower voltage drop. This is a significant feature which promises more than the idea that a much greater wattage can be obtained in a given installation. To illustrate this, the diagrams on page 214 show the theoretical wattage that some representative conduits can carry, and the circuit length of wire (half the total length for two-wire circuits) that could be utilized under those conditions. As this length is exceedingly short, the practical advantage certainly seems to be that of carrying the same size of load as at present, but with less drop, by the introduction of a small diameter wire.

In the larger sizes of cable, where the temperature has been the limiting factor, the situation is considerably improved. Cables are now available that can be utilized for carrying the full rated load as indicated in the tables and correction factors for numbers of wires, without requiring a layout engineer to make additional reductions based on unfavorable experience with the deterioration of the insulation.

It is hoped that these new wires will help all of us enjoy to the fullest the advantages that the increased use of electricity permits.

Voltage-Operated Earth-Leakage Protection

THE PAPER "Voltage-Operated Earth-Leakage Protection" by T. C. Gilbert, deals with the problem of protection of low-voltage distribution systems from the standpoint of practical experience rather than from a purely theoretical basis, particularly for secondary systems on customers' premises. The author discusses the protection of secondary systems quite thoroughly and sets up the relative importance of the various factors in the problem, such as fire risk, shock hazard, cost of the installation, etc., but with greatest emphasis on the fire risk, since in rural areas this presents the greatest menace.

The limitations of multiple neutral grounding are presented, together with what the author believes to be the only really practical alternate, that of using voltages of the neutral to ground as an indication of an abnormal operating condition, and applying this voltage to a trip coil to disconnect the service by automatically tripping the customer's circuit breaker. Diagrams and pictures of the devices are included. The author refers to English, German, and Swiss practices and quotes excerpts from publications of various governments and others to support his views.

The widespread development of rural electrification has focussed considerable attention on the matter of adequate protection of customers' services. The hazards accompanying rural installations are particularly pronounced because of difficulty in maintaining proper standards of installation, the lack of central water supply systems, the difficulty in effectively fighting fires, and the large number of buildings with inflammable contents on the premises of rural customers.

One fundamental difference which must be considered in comparing British and European practice with that in the United States is the lower service voltages commonly in use here. The foreign practice is to employ 220/380 volts three-phase system, giving single-phase voltages to ground of 220 volts, or double that which would usually be experienced in installations in the United States.

For many years experience in England and elsewhere has tended to establish the use of conduit continuously bonded and grounded throughout as the safest form of construction. In the light of experiences cited by the author, considerable doubt is expressed as to the adequacy of installations of this type, even though it would appear to be about the ultimate in freedom from hazards of all types. Multigrounding the primary as well as the customer's secondary (called "protective multiple earthing", by the author) has been considered as giving the maximum protection against dangerous voltage rise when the secondary conductors are enclosed entirely in metallic conduit.

The use of multiple grounds was primarily developed for the protection against personal shock hazard, and while this may have been accomplished to a considerable extent by overcoming the difficulties of obtaining low resistance to ground at isolated locations, the problem of fire hazard appears to have been considerably aggravated. The problem of fire hazard is further complicated by increasing loads on customers' services, resulting in the use of large fuses, thereby nullifying protection against ground faults. Even if careful tests and inspections are made on the original installation, experience has shown that the resistances of metallic structures such as conduits and water pipes do not stay constant but rise over a period of years. This has been found to be the case even in the use of many gauge threaded joint conduits.

The particular function of multigrounding then is to provide an over-all low resistance to ground through all available ground connections in parallel. Line-to-ground faults may then result in sufficient current to operate protection and to restrict the voltage rise of neutral conductors above ground to safe limits. Theoretically, this type of construction should produce the desired results, but because of breaks in the neutral conductors or higher resistances in the neutral circuit, the earth-return path may

Abstract of a paper of the same title, prepared for the Institution of Electrical Engineers of Great Britain by T. C. Gilbert and abstracted by Frederick Von Voigtlander (A'29, M'38) electrical engineering department, Commonwealth and Southern Corporation, Jackson, Mich.

become one of considerable resistance, particularly in rural areas where detection and maintenance are difficult. Even if the earth-return circuits were of low resistance, experience has shown that nonelectrical metallic circuits may carry considerable current, as cited in the report of the American Water Works Association, and as a result there is the possibility of hot spots developing and the possibility of sufficient current flowing in accidental contacts between gas pipe and conduit, or other metallic structures carrying electricity, to result in damage to such structures either by electrolysis or by fusion at the point of contact.

It therefore follows that multigrounded secondary installations do not accomplish the purpose for which they were developed. The author proposes, as a possible solution to the problem, the use of a device operated on the difference of potential between the neutral conductor and an auxiliary ground to trip the customer's service breaker whenever such a potential exceeds a predetermined minimum. The neutral potential is measured to an auxiliary ground which can have quite high resistance, as only from 60 to 80 milliamperes are required to operate the neutral voltage relay. If 65 volts between neutral and ground were considered the maximum allowable, the circuit could contain a total impedance of close to 1,000 ohms. With the resistance and reactance of the relay coil itself each equal to, say, 200 ohms, the system would operate satisfactorily for an external grounding resistance of the order of 700 ohms. This would provide adequate protection by the use of ordinary driven grounds of the simplest sort. The author cites experiences, particularly in Germany, where such installations have been carried out on a large scale which over a period of 16 years have been found to be very satisfactory.

A further development of this device includes its application to switches controlling heavy appliance outlets to which customers connnected portable tools, farm machinery, etc. Such switches were equipped with the automatic earth-leakage trip devices each having its own voltage trip circuit connected to ground through individual ground rods at the devices.

Such switches, in combination with overcurrent protection, could also be installed on outlets serving water heaters, electric stoves, washing machines, and similar appliances having large metal areas exposed to physical contact, thereby greatly reducing the hazard of personal injury and shock in their use.

The use of neutral voltage operated devices of this type to automatically de-energized customers' services for ground fault enhances the advantage of nonmetallic conduit and nonmetallic sheathed wires which, in the author's opinion, from the standpoint of cost, shock hazards, fire hazards, and maintenance, are in every way superior to the use of multiple grounded neutrals and rigid metallic conduit installations.

Library Versus Laboratory Research

HEARING the word "research", the layman pictures a serious-faced individual in a laboratory, surrounded by mysterious apparatus. Popular conception has a laboratory the essential background, even though that is not the most important or most fertile field for research in many branches of science today.

Science has another setting for research—the library. When scientific literature was lacking or very meager, research necessarily meant laboratory investigation above all else. Today, scientific literature has attained tremendous proportions, and increases much faster than it is digested and efficiently utilized. For that reason it should prove advantageous for the present-day research worker to spend much more time in the library, and correspondingly less in the laboratory, than is the general custom.

Library research would overcome two serious errors often made by scientists, duplication of work described completely and failure to appreciate inventions described almost verbatim in the literature.

Annual reports of the Secretary of Commerce over a period of years indicate that about 30 per cent, more than 15,000 each year, of the patent applications filed are abandoned. The predominant reason for abandonment is that the subject matter disclosed in the application has already been described in published literature. Without question, the annual bill to industry for abandoned applications amounts to several million dollars. Practically every dollar might have been devoted to pioneer research to extend frontiers of our knowledge at a faster and more profitable rate than is now the case. Time would have been saved for all concerned had the literature been thoroughly investigated in the beginning.

Many a scientist is too busy accumulating data to take time for a complete and analytical evaluation of either his own or published data of others. As a result scientific literature increases at an amazing rate and many important inventions are submerged in it. Some of the most important inventions of this era were discovered years after they had been described almost in their entirety in the scientific literature. The last step only was missing, and it took years for the scientist to supply it from the laboratory.

With proper balance and co-operation between the laboratory and the library scientists, millions of dollars wasted annually in repeating old investigations will be saved. The stream of data continually increasing the volume of scientific literature will be carefully searched, correlated and efficiently utilized. Important inventions will be speedily skimmed from the literature instead of reposing unknown and unused. Our industrial research will then attain a new efficiency peak and frontiers of knowledge will expand more rapidly than ever before, to the advantage of scientists, industry, and civilization.

Abstracted from "Library Versus Laboratory Research", by Arthur Connolly, *Industrial and Engineering Chemistry,* October 25, 1940.

Applications of Electric Power in Aircraft

T. B. HOLLIDAY

As a national defense problem of primary importance, the needs of the aviation industry offer a challenge to the designers and manufacturers of electrical equipment. The author lists the following as some of the important needs already recognized, and warns that others may be expected to develop.

1. Engine-driven generators with greater output or decreased weight.

2. A constant-speed drive that would permit the use of alternators with variable-speed prime movers. To meet proper future power needs, this drive should be designed to transmit 30 horsepower and should weigh not more than 30 pounds.

3. Lighter-weight batteries. Unless these can be designed, the aviation industry will be forced to discontinue the use of batteries.

4. An accessory power plant to deliver 7.5 kw, with weight of from 70 to 80 pounds, small size, and reasonable cost.

5. Electric motors with the smoothness and ease of control which characterize hydraulic equipment.

6. Positioning motors that permit accurate remote control of various devices. Present positioning motors are somewhat heavier than is desirable.

7. Radio equipment designed to minimize the problems of installing other electric equipment.

8. Smaller sizes of cable. The development of flame-proof cable and of cable that can withstand more severe usage also would increase reliability of electrical distribution systems.

9. Electric equipment that duplicates the action and smoothness of the hydraulic jack.

10. An electrically operated substitute for hydraulic and pneumatic wheel brakes.

11. Improved circuit-protection devices.

APPLICATIONS for electric power in modern aircraft are many. In nearly every case these applications represent special problems in which the electrical industry as a whole has taken extraordinarily little interest. As a result, the aviation industry has been forced to obtain electrical equipment from manufacturers of special equipment, who are not necessarily the best designers of electrical apparatus. As a result many other types of accessory power have been used for duties which electric power could quite easily perform.

In its simplest form an airplane consists of a fuselage with supporting wing surfaces, a power plant for propulsion, and landing gear for operation on the ground. Any item of equipment which is in addition to the basic airplane and which is not essential to flight can be classified as an "accessory". The purpose of these accessories is to increase the performance of the airplane, provide greater safety, increase reliability, and make the task of operating the airplane an easier one.

These accessories are operated by various types of power: manual, electric, hydraulic, pneumatic pressure, pneumatic suction, mechanical, a combination of these and in some cases the use of gas under pressure. It is the purpose of these types of accessory power to transfer energy from one part of the airplane to another. In nearly every case the basic source of energy is the aircraft power plant which also drives the propeller.

Table I lists many of the accessories of the modern airplane and the types of accessory power used to operate them.

It will be noted that for the first five types of power the engine is the prime mover. In the case of manual power the pilot is the source, and the last, which is termed "combustion" means the product of ignited powder. Of the accessories listed, lighting, radio, and intercommunication equipment can be operated only electrically. For this reason it is essential that the aircraft include a source of electric power. All the remaining accessories can be operated electrically, and in some cases manually as well.

Some combinations of power will be noted. For example, de-icing equipment is operated by an air pump direct-driven (mechanical) by the main engine to deliver pneumatic pressure to rubber boots on the wing-leading edge or other surface from which ice is to be removed. An electric motor also can be used in combination with the air pump.

Obviously it will be to the advantage of the aviation industry to reduce the number of types of accessory power to a minimum, thus reducing the number of power take-offs that must be provided on the aircraft engine. When selecting the type of accessory power, certain characteristics must be considered. The system must be reliable, because in many cases the completion of the flight mission is dependent upon the accessory. Obviously the equipment must be light in weight, because a reduction in weight of the accessory equipment means that more payload or more fuel can be carried. The saving of one pound has an unbelievably high theoretical value in commercial aviation. The installation should be such that maintenance and replacement of items are relatively easy. The cost should not be exorbitant, although cost is usually subordinated to such requirements as reliability and weight. In military aircraft vulnerability is an im-

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portant consideration. For that reason an accessory system should be selected which can be duplicated. Additional characteristics that are desirable but too often sacrificed are available power on the ground, ease of control, and quick response.

A comparison of the three most commonly used types of power, electric, hydraulic, and pneumatic, shows that the hydraulic system has many advantages which amply justify its use in aircraft, but also has certain disadvantages, particularly in military aircraft, which make the development of equivalent electric equipment highly important.

The reliability of the electrical system is rather good, although difficulties encountered in service are many and varied. These are approximately evenly divided between electrical and mechanical failures. Until 1939 the weight of generators and motors could be fairly considered as a disadvantage, but under the leadership of a major manufacturer in the electrical industry these weights have been reduced astonishingly. Electric power has many basic advantages in efficiency, cost, and avoidance of operating difficulties at high altitude and low temperature. It is to be regretted that its other characteristics have not kept pace with those achieved by competitive types of power.

Further discussion will be confined to the electrical system. The conventional practice in the past has been to use generators mounted on and driven by the aircraft engines which are operated in parallel with lead-acid batteries. This d-c system had a normal rating of 12 volts until 1939. At that time practically all new military and commercial airplanes were designed with a 24-volt d-c system. The battery is needed primarily as a reservoir of electric energy for starting the aircraft engines. D-c power is needed because aircraft engines are variable-speed prime movers. To operate the generators in parallel a voltage-regulated d-c system is necessary. Engine speed varies from a maximum at take-off, which is approximately 120 per cent of rated speed, to an operating speed of approximately 60 per cent during cruising at maximum fuel economy. This means that the generators must operate satisfactorily throughout a 2-to-1 speed range.

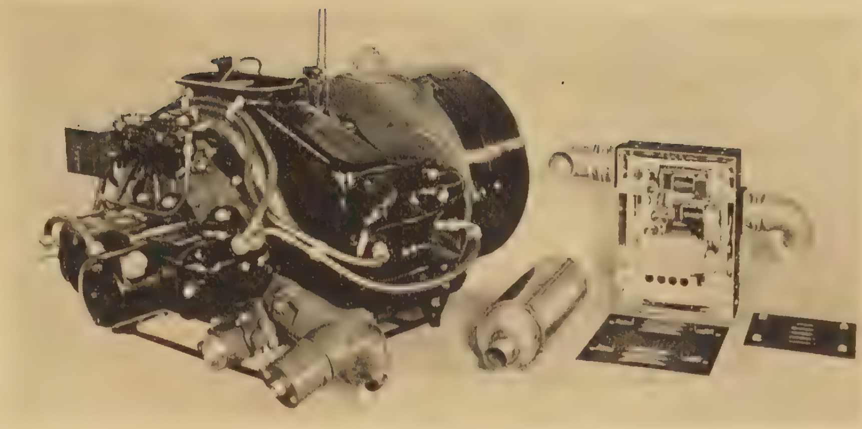

Figure 1. D-c accessory power plant, 5 kw, 28.5 volts, consisting of a two-cylinder internal-combustion engine with a comparatively flat generator mounted on the engine crankshaft

Table I. Methods of Operating Aircraft Accessories

	Electrical	Hydraulic	Mechanical	Pneumatic Pressure	Pneumatic Vacuum	Manual	Combustion
Engine: Starter	x			x		x	x
Radiator shutters	x					x	
Fuel pumps	x	x	x			x	
Tachometer	x		x				
Controls						x	
Synchronizer	x						
Propeller: Pitch changing	x	x	x				
Constant speed controls	x						
Anti-icing	x						
Wheel retraction	x	x	x			x	
Wheel brakes		x		x			
Flap mechanism	x	x	x			x	
Flying controls						x	
Radio	x						
Lighting	x						
Intercommunication	x						
Fuel transfer	x					x	
Heating	x						
Fire extinguisher						x	
De-icing	x*		x*	x*			
Gyroscopic instruments	x				x		
Remote instruments	x						
Automatic pilot	x	x*			x*		
Cabin supercharging			x*	x*			
Machine guns	x		\				
Machine-gun rearming	x			x			
Bomb release	x				x		
Bomb doors	x			x	x		
Camera	x				x		

*Combinations of power, see text

GENERATORS

The space allowed for installation of generators on the aircraft engine is limited. In no case can the diameter of the generator exceed six inches, since other accessories and engine auxiliaries must be mounted on and driven by the same rear section. These other accessories and auxiliaries include the engine starter, one or two magnetos, the hydraulic-system oil pump, the pneumatic-system air pump, fuel pump, engine oil pump, tachometer drive, and miscellaneous synchronizing drives. Generators having a maximum weight of 38 pounds have been installed on engines. However, one type of engine caused generators weighing only 32 pounds to shear four 5/16 mounting studs, due to excessive vibration. The number of mounting studs has been increased to six, but it is still preferred to restrict generator weight to approximately 35 pounds. Until approximately two years ago the maximum output needed from a single generator was 50 amperes at 15 volts. This generator was operated with the so-called 12-volt system and was actually set at 14.25 volts properly to charge the batteries. It had an output of 750 watts and weighed 32 pounds.

By doubling the operating voltage and standardizing on a 24-volt system a generator having the same current rating was obtained for a weight of 34 pounds. This

Table II. Current-Time Performance of Batteries

Current	Time in Minutes to Reach End Voltage 22 Volts	18 Volts
24-Volt 70-Ampere-Hour Battery, Weight 140 Pounds		
50	60	75
100	20	60
200	1.5	11
300	0.8	6
24-Volt 35-Ampere-Hour Battery, Weight 80 Pounds		
50	12	30
100	0.9	10
200	0.4	2
300	0.2	0.6

represented a reduction in specific weight per kilowatt to almost half that previously used. Further development in generators during the current year has resulted in the production of a 100-ampere 30-volt machine (3 kw) weighing only 32 pounds. There is now under development a 200-ampere machine which utilizes additional forced cooling from the slipstream and which will weigh only 37 pounds. This generator represents a specific weight of approximately 6 pounds per kilowatt compared with the 44 pounds per kilowatt previously used. The efficiency of these machines is approximately 75 per cent. They are designed for a minimum speed of 2,500 rpm and must provide accurate voltage regulation to 4,500 rpm. With the expectation that still greater amounts of electric power will be needed within the next five years, engine design is now being revised to provide a higher generator-drive speed.

BATTERIES VERSUS ACCESSORY POWER PLANTS

Batteries are used primarily as a reservoir of electric energy for starting the main engines. The characteristics of batteries which are normally used in aircraft are shown in table II. Consideration of the currents shown in the table clearly indicates that batteries can hardly be considered as a source of assisting power to high-output generators. A battery weighing 140 pounds will deliver 200 amperes at 18 volts or more for only 11 minutes. A generator weighing only one-fourth this amount will deliver 200 amperes continuously and 300 amperes for 5 minutes at 28 volts instead of 18 volts.

Another characteristic of batteries which prejudices against their use is the increase in weight with increase in voltage. A 34-ampere-hour 12-volt battery which has been in use for the past ten years weighs approximately 38 pounds. When the system voltage was doubled it was found that a 24-volt 17-ampere-hour battery, which has the same watt-hour capacity, weighed 56 pounds. This increase in battery weight more than offset other gains which were made with the increase in voltage.

Consequently, it may be necessary to use small engine-driven generators commonly described as accessory power plants instead of batteries, in starting the main aircraft engines. Experimental units of this type have been developed which provide 5 kw continuously and 7.5 kw intermittently in a weight of 140 pounds, which is practically the same as that of a 24-volt 70-ampere-hour battery. The latter will deliver 200 amperes at 18 volts for 11 minutes. The accessory power plant will deliver 175 amperes continuously and 275 amperes for 5 minutes at 28 volts.

Accessory power plants have been developed by the Army Air Corps, the Navy Bureau of Aeronautics, and to a limited extent by commercial aviation interests, with the idea that small engine-generator units could be installed in duplicate in larger airplanes and used as the primary source of electric power, thus making available higher power, higher voltage, and alternating current. The small gasoline engine also could provide power on the ground eliminating batteries. In addition, if electric power were used to distribute energy throughout the airplane, many accessories could be removed from the main engine, simplifying its installation and maintenance.

The Air Corps procured an engine which was rated 30 horsepower at sea level and 12 horsepower at 20,000 feet. The complete installation of two engine alternator units to deliver approximately 13 kw of power weighed 640 pounds. Each engine alone weighed 240 pounds. Subsequent development and procurement have proved that it is entirely possible to provide an equivalent engine with less than 40 per cent of this weight. Difficulties encountered with the first installation were numerous. The flexible coupling installed between the small high-speed engine and the alternator gave trouble because the angular acceleration which resulted from a comparatively small number of cylinders imposed high stresses on these parts. The use of high-frequency alternating current encouraged the development of electric motors operating at a synchronous speed of 24,000 rpm, and this high operating speed caused many failures, all due to failure of lubricants. Most of these troubles have been solved, although the first system cannot be relied upon for continuous use for more than 150 hours without maintenance.

Development of similar d-c accessory power plants has

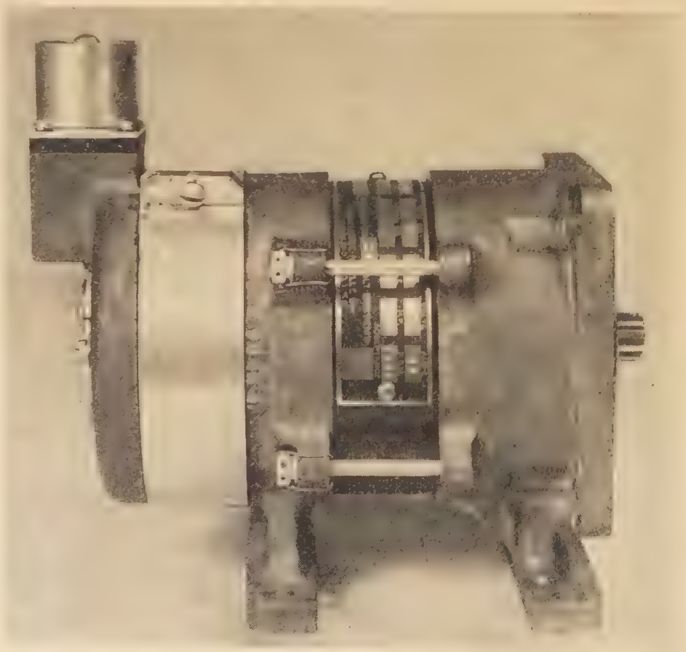

Figure 2. D-c motor, 24 volts, 0.4 horsepower, 2,500 rpm

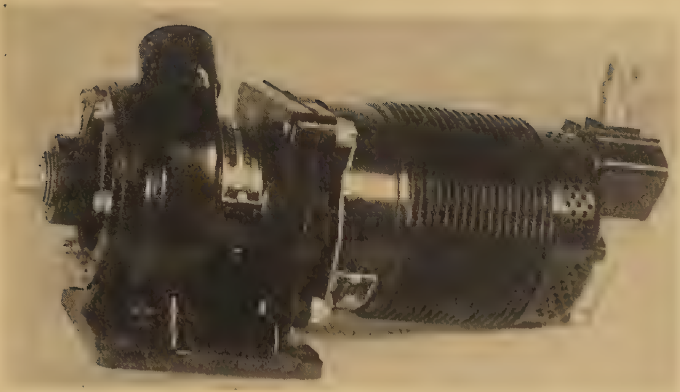

Figure 3. Motor-driven centrifugal fuel pump

The eight-pole three-phase 400-cycle 110-volt motor has a rating of 1.5 horsepower at 5,700 rpm

resulted in a 5 kw, 28.5-volt unit weighing 140 pounds, which occupies a space 22 inches long, 20 inches wide, and 14 inches high. This power plant is internally supercharged, so that it delivers 80 per cent of its normal rating at 20,000 feet altitude and 150 per cent at sea level. However, operating altitudes now are far above 20,000 feet. In so far as application in military airplanes is concerned, increase in operating altitude in the past three years make it impracticable to consider accessory power plants as the primary source of power. Operating altitudes have increased to 35,000 and 40,000 feet with the use of supercharged cabins for personnel. At such altitudes a supercharger adequate to maintain the necessary electric output from the accessory power plant will be nearly as large as the small engine itself.

The parallel development in engine-driven generators has made it possible to obtain 6 kw from a machine weighing only 37 pounds. A separate engine-driven accessory power plant to deliver the same rating at these altitudes would weigh nearly 200 pounds. The choice is obvious. Vulnerability also affects this selection. In a four-engine airplane, four small d-c generators on the main engines would be a much smaller target than would the equivalent accessory power plants. Four generators would be provided, while it is doubtful if there would be space for more than two accessory power plants, each of which must necessarily have twice the rating of the units driven by the main engines. Loss of one of four generators would be far less important than the loss of one of two accessory power plants.

APPLICATIONS OF ALTERNATING CURRENT

The use of a-c power, developed with the accessory power plants described, proved to have many advantages. For example, a-c power made it possible to provide remote indicating instruments which greatly simplified the transfer of an indication of engine operating conditions to the pilot's instrument board. With previously used instruments, mechanical tachometer shafts, oil-pressure and fuel-pressure lines had to be conducted from the engine compartment to the pilot's board. These lines were vulnerable points in the engine control system.

In addition, the development of fluorescent lighting for instruments was assisted by the availability of a-c power. Improper lighting of instruments causes glare in the pilot's eyes and impairment of vision when it is needed most. The development of instrument lighting progressed from so-called direct lighting to masked indirect lighting and finally to incorporation of a small surgical lamp in each instrument. This last method was the most satisfactory, but was very expensive, since a lamp costing approximately $1 must be installed in each instrument, and wiring conducted thereto. Fluorescent lighting uses ultraviolet radiation to cause radium paint or special paint to fluoresce. This provides ideal lighting, since the numerals on the instrument dial become the source of light and there is no glare.

A-c applications for the operation of radio equipment and gyroscopic instruments are now under development. The latter have been operated in the past by means of pneumatic suction. Use of high-frequency a-c power will make it possible to drive the rotor of these instruments as an induction motor.

These applications for a-c power, which were discovered in experimental development of accessory power plants with a-c systems, are of equal advantage in airplanes whose primary source of electric power is direct current. To provide a-c power in these airplanes various types of inverters have been developed. For the remote indicating instruments inverters were originally designed for 32 volts and 60 cycles. It was found possible to reduce the weight of this equipment considerably by operating the instruments at 120 cycles with a corresponding increase in voltage. The vibrating-switch type of inverter has proved successful for this application. It was necessary to provide adequate filtering to prevent radio interference and to redesign the electric circuit to insure the needed reliability. This type also has proved an excellent source of power for fluorescent lighting. For gyroscopic instruments, however, a higher frequency was needed. For reasons to be discussed later 400-cycle power is advantageous. The highest practical value thus far produced for vibrating-switch type inverters is 200 cycles. For this reason it appears that 400-cycle inverters must be rotating machines, which are being developed in ratings from 100 to 1,500 volt-amperes with efficiencies of approximately 75 per cent and weights from 8 to 20 pounds.

MOTORS

The principal items of equipment to receive power are electric motors of various types. Motors have been used for operation of such accessories as landing gear, flaps, pump units, valve mechanisms, etc. Their use as a continuously operating drive has come only in the last two years. The mechanical drives, such as landing gear and flaps, are intermittent-duty applications. Most of the pump drives are continuous-duty applications, although in such instances as propeller-feathering pumps the duty is intermittent. In the operation of de-icing equipment, electric motor drives have the greatest advantage. Operation of the de-icing air pumps from a mechanical drive on the main engine means that they will be operated con-

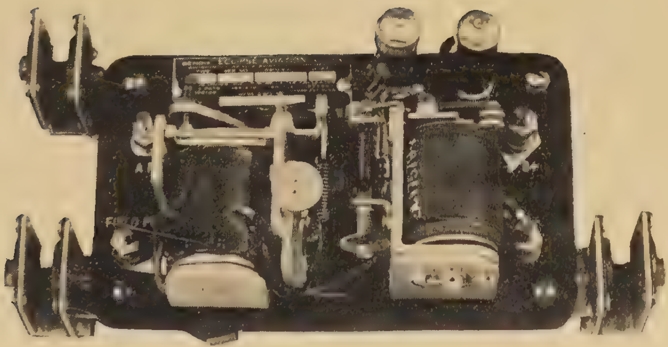

Figure 4. Control panel, 8 inches long, consisting of a voltage regulator and reverse current relay, for 50-ampere 15-volt engine-driven generator

tinuously although flight in de-icing conditions occurs during a very small portion of the time. When the pump is driven by an electric motor, it is used only when those conditions are encountered.

Electric motors for operation of fuel pumps are being developed at the present time and show much promise. For this application it is necessary to provide a motor of explosion-proof construction. In most cases these motors have been constructed to requirements of the Underwriters' Laboratories, but these have proved unnecessarily severe for aircraft duty. They are based on industrial practice and are intended for use with motors having a relatively large internal volume. For aircraft a motor necessarily must be as small and light as practicable. The imposition of bearing-length and flange-construction requirements necessary for industrial motors on aircraft motors which have a volume of only 1/100 of the equivalent industrial motor is unnecessarily severe. Research is being undertaken to determine more reasonable design characteristics so that explosion-proof construction will not make the weight and size of the motor prohibitive.

Some work has been done in recent years on the development of a motor which will transfer accurately a desired position of a driven device. Remote indicating instruments are representative of this type, but their characteristics are such that no usable torque other than movement of a needle can be transferred. A positioning motor is one that will deliver any desired amount of torque and position accurately a device at a remote location by the operation of some transmitting device at the pilot's cockpit. The simplest type of equipment for this purpose consists of a potentiometer at the pilot's control board and a motor at the driven device with a corresponding potentiometer. Setting the control potentiometer automatically causes the motor to start and drive the device and the second potentiometer in the proper direction again to neutralize the control voltage. This type of equipment has many applications, the largest of which is the landing flaps. With such a motor the pilot need only set a potentiometer at the position corresponding to the desired setting of the flaps, for example, 40 degrees, and the motor will start and drive the flaps to this position without further attention by the pilot.

Many types of motors are needed for aircraft. The landing gear and flap motors described are primarily torque motors designed for intermittent duty. For this application the series-wound motor has proved best. For continuous-duty applications with pumps, where speed regulation is an important characteristic, the shunt-wound motor is superior. Explosion-proof construction is required for motors used with fuel pumps and propeller anti-icing fluid pumps. In most cases the series-wound motors used with intermittent-duty applications must be designed for reversing. In the past this has been accomplished by use of two series fields. However, present indications are that the use of a double-pole, double-throw relay with a single-field motor will provide some saving in weight in the motor and considerable saving in weight of the wiring.

Curves showing the weights and efficiency of d-c motors to conform to Air Corps specifications are shown by figures 5 and 6. Similar curves for a-c motors are shown by figures 7 and 8. As motors have been procured which exceed the performance and weights required by these curves, they are believed to be quite conservative. Points which represent such motors are plotted on these figures and connected to the corresponding point which represents Air Corps requirements. An interesting point with regard to the operating speed of a-c motors can be noted from figure 3. A motor operating at 24,000 rpm and designed for only intermittent duty weighs only one-half as much as a motor designed for continuous duty at a synchronous speed of 4,000 rpm. Therefore, the increase in speed of 6 to 1 has resulted in a saving of weight of less than 2 to 1. For this reason, further applications of a-c motors will discourage the use of excessive speeds with their problems of lubrication and life. It is entirely practicable to construct an a-c motor for continuous duty at 12,000 rpm, which will have an operating life of 1,000 hours. At the present time it is considered to be impracticable to accomplish the same result at 24,000 rpm.

DISTRIBUTION SYSTEM

Problems involved in the electrical distribution system can cause excessive costs, production delays, and unreliable performance, unless they are carefully controlled. The cable normally used in Army aircraft wiring for distribution of electric power requires two layers of varnished cambric, oppositely wound, covered with varnish-impregnated fabric. The weight and size of this cable are shown by table III. The gauge size is AWG. The

Table III. Weight and Size of Cable

Gauge	Diameter Over-all	Diameter Conductor	Weight (Pounds Per Foot)	Rating
22	0.090	.032	0.003	1
20	0.126	.041	0.006	2
18	0.136	.050	0.009	5
16	0.146	.060	0.012	10
14	0.166	.080	0.018	16
12	0.186	.100	0.026	23
10	0.208	.120	0.054	35
8	0.250	.150	0.090	45
6	0.300	.190	0.110	65
4	0.370	.240	0.180	90
2	0.440	.300	0.238	125
0	0.525	.380	0.360	200

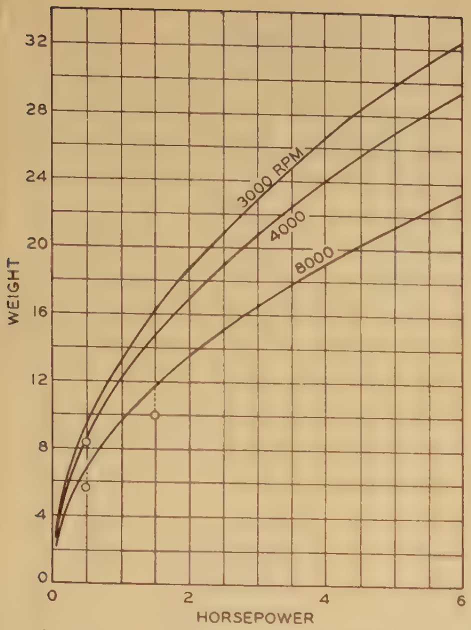

Figure 5. Weight versus power, d-c motors

$$Wt=\left(12\sqrt{hp}\times\sqrt[3]{\frac{4{,}000}{\pi}}\right)+0.1$$

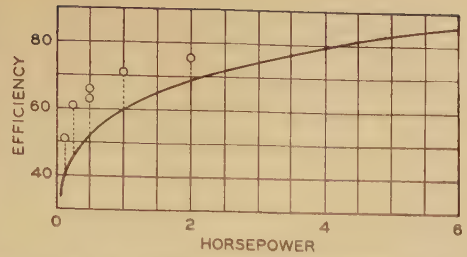

Figure 6. Efficiency versus power, d-c motors

$$Eff=\sqrt[5]{hp}\times 60$$

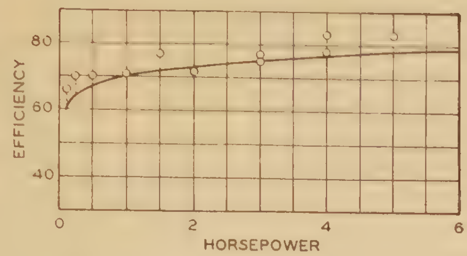

Figure 7. Efficiency versus power, a-c motors

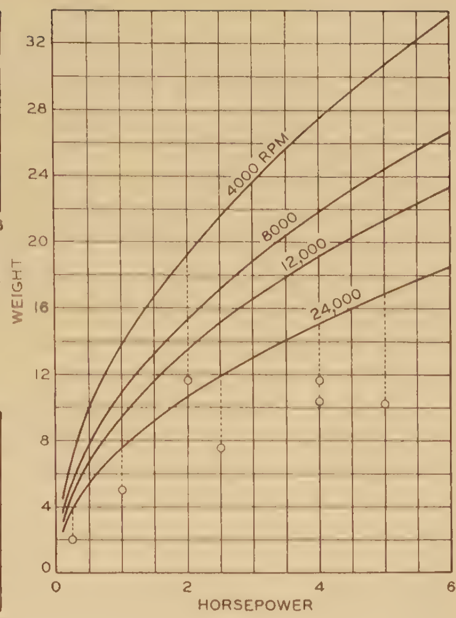

Figure 8. Weight versus power, a-c motors

weight per foot of the cable is tabulated, as is the current rating normally permitted.

The size of cable used for an individual circuit depends upon the length of that circuit. Normally, continuous-duty loads are required to have a voltage drop of less than three per cent. The maximum current permitted in a given size of conductor is that tabulated in table III. These currents may be doubled if the duty is intermittent. The insulation required on this cable is adequate for any voltage heretofore used in aircraft for power, and is required more for mechanical protection than for its insulation properties. For this reason the same cable has been used in 12-, 24-, and 110-volt electrical systems. The minimum size of cable is determined by its mechanical strength. For many years a size smaller than number 18 was not permitted, because pulling cable through conduit broke smaller sizes. Number 20 has been permitted in recent years. Number 22, referred to in table III, is a special cable using rubber insulation which is permitted only in instrument-lighting circuits where the conduit run is very short.

The methods used to reduce radio interference with the electrical distribution system have been based upon insufficient understanding of the problem. Radio interference is a quantity which is very difficult to measure and which probably has been given undue consideration. In the past the practice of the aviation industry has been to require as nearly perfect electrostatic shielding as can be incorporated in the airplane, and that this shielding be bonded to the structure as often as practicable. The resulting installation is heavy, difficult to install, and consequently very expensive. The shielding usually has been provided by a system of conduit, both rigid and flexible, in combination with aluminum boxes. Table IV shows the weight characteristics of various types of flexible conduit. This conduit usually consists of aluminum alloy armor covered by a woven braid of aluminum alloy or tinned copper wire. In case resistance to moisture is important, this conduit may be obtained with a thin coating of rubber. The increase in weight caused by the conduit can be estimated by assuming that the weight of tinned copper conduit approximately equals that of the wiring which it encloses. The weight of wiring in typical airplanes is given in table V.

Radio-equipment manufacturers have made no effort to shield their equipment in a way that takes advantage of the all-metal aircraft structure. Proper shielding of the antenna lead-in and radio equipment, with use of the airplane structure to shield interference originating within the fuselage, would seem to be entirely practicable. The metal structure of fuselage and wings would take the place of the aluminum conduit now used, and it would be necessary to provide conduit as a means of mechanical support only. From 900 to 2,000 bonds are now required to ground the shielding system, as well as parts of the airplane structure. As the engineering and installation costs of these bonds may be approximately $1 each, a considerable saving can be achieved simply by reducing their number.

While the requirements for radio performance in aircraft must be high on account of the great range in frequency and distance, there is considerable reason to doubt the necessity for the elaborate installations which have been made in the past. It is hoped that, with improvements in radio equipment and filtering, the electrical system in the airplane can follow automotive practice more closely than heretofore.

Another problem encountered primarily in military aircraft is that of vulnerability of the electrical system. A group of circuits confined in one conduit for the purpose of reducing radio interference and mechanical support is a highly vulnerable target. For that reason, military air-

craft is likely to sacrifice freedom from radio interference to decreased vulnerability. Perhaps this will force the development of radio equipment that does not need the expensive shielding system used previously.

One of the most important advantages of electric power is that the distribution system can be made self-protecting and so designed that any failure automatically is isolated. In the past, this result has been achieved by means of fuses. However, the equipment available thus far is not entirely satisfactory. The automotive-type fuses which use tinned copper clips on the end of a glass or phenolic case do not withstand service usage as well as desired. The clips develop a high resistance contact which causes premature failure of the fuses. This type of failure was eliminated by using fuses which had lugs adapted for mounting studs, but the fuses were so large that aircraft manufacturers objected. Circuit breakers have been considered for this duty, but to date none has been demonstrated which satisfactorily duplicates the action of a fuse.

For control of the distribution system, small toggle switches and relays are normally used. The switches occupy a space approximately 2 inches long by 3/4 inch wide by $1^1/_4$ inches deep. These are available in both single- and double-throw designs and with a variety of operational combinations. Relays suitable for use in aircraft are scarce. Relays are not justified until the circuit load exceeds 25 amperes. Commercial relays designed for currents between 25 and 200 amperes are much larger than necessary. In addition, they must be designed to withstand vibration, temperature, altitude, and other characteristics of use in aircraft.

The distribution of cable in three sizes of aircraft is shown by table V. Reference to this table shows that most of the cable in use is in the smaller sizes, 16 to 20. The total weight of the respective sizes for the size of airplane under consideration is also tabulated. While a great length of cable is used in the smaller sizes, the weight of the larger sizes exceeds that of the smaller. This demonstrates most effectively the advantage of higher operating voltages. All the airplanes for which consideration is given in table V have 12-volt electrical systems. The decrease in weight of wiring alone made possible by use of an equivalent 110-volt d-c system is shown in the table.

Table IV. Flexible Conduit

Size in Inches		Weight (Pounds Per Foot)		
ID	OD	Aluminum Alloy	Tinned Copper	Rubber Covered
1/4	0.390	0.048	0.0717	0.154
3/8	0.515	0.065	0.0871	0.193
1/2	0.640	0.084	0.1130	0.242
5/8	0.765	0.098	0.1428	0.280
3/4	0.920	0.139	0.1832	0.380
1	1.210	0.193	0.2745	0.514
1 1/4	1.463	0.233	0.3524	0.638
1 1/2	1.716	0.278	0.4700	0.750

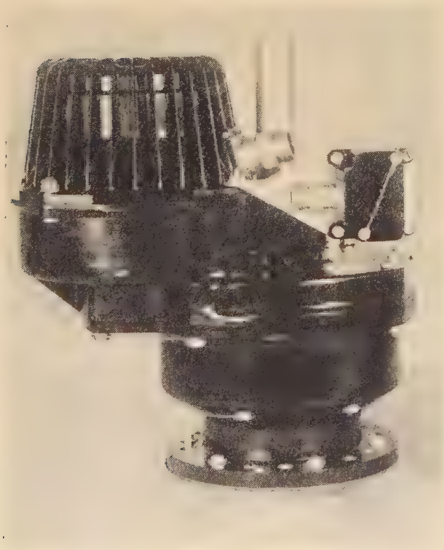

Figure 9. A-c engine starter designed for use with 110-volt three-phase 400-cycle power

A flywheel, of which the rotor is a part, is accelerated to 12,000 rpm, when the energy thus accumulated is released through a clutch to the engine crankshaft

DIRECT VERSUS ALTERNATING CURRENT

There has been a great deal of discussion in the past four years regarding the comparative advantages of direct and alternating current for use in aircraft. D-c power can easily provide a reservoir of energy in the form of a battery and its use is comparatively familiar, since the system is very similar to that used in the modern automobile. As to disadvantages, d-c systems which use a battery are practically confined to a relatively low voltage, which means a heavy distribution system. The use of low voltage places a definite limit on available power, since conductors which carry more than 200 amperes continuously without excessive voltage drop are too heavy to be of any value in aircraft. The question of commutation at altitude has not been completely decided. It is known that arcing, which is practically negligible at sea level, becomes a serious matter in the ionized air of the substratosphere. Whether this is a serious condition has not yet been determined. The weight of d-c equipment is somewhat greater than that of the a-c equipment of the same power and speed. Likewise, the efficiency is lower.

A-c power has the advantages of light weight and flexibility of voltage. The latter is of particular importance to manufacturers of radio and lighting equipment. Some prospective users of a-c power have cited as an objection the fact that the high frequency will cause a noticeable hum in radio-receiver equipment. That this need not occur has been proved by the Army Air Corps with use of both 800- and 400-cycle equipment and by the commercial aviation industry with 800-cycle equipment. In each case it was found very easy to filter out the a-c hum. The filters were more easily constructed than equivalent filters to reduce the noise caused by d-c commutation. The higher voltages readily obtained with a-c generators permit a greater application of small-cable sizes, thereby greatly reducing the weight of the distribution system. The elimination of commutators increases the safety of the system, particularly when used with fuel pumps, and increases the operating life of equipment. Practically no maintenance will be needed for a-c motors and transformers, except lubrication of the motors, whereas brush-life as well as lubrication determines the operational periods for d-c motors and dynamotors.

Table V. Distribution of Cable in Three Sizes of Aircraft

Size AWG	Single Engine No. Pieces	Single Engine Length Feet	Single Engine Weight (Pounds) 12 Volts	Single Engine Weight (Pounds) 110 Volts	Two Engine No. Pieces	Two Engine Length Feet	Two Engine Weight (Pounds) 12 Volts	Two Engine Weight (Pounds) 110 Volts	Four Engine No. Pieces	Four Engine Length Feet	Four Engine Weight (Pounds) 12 Volts	Four Engine Weight (Pounds) 110 Volts
0	6	25	9.0		14	99	36					
2	4	6	1.4		5	39	9.3		62	430	102	
4	4	10	1.8						3	70	12.6	
6	10	40	4.4		14	124	13.7		34	334	36.6	
8	14	88	7.9		11	48	4.3		24	185	16.7	
10					42	299	16.2		8	70	3.8	
12	54	385	10.0		4	33	0.9		53	384	10.0	
14				0.6	7	55	1.0	2.5				7.8
16	55	585	7.0	0.6	193	1,524	18.3	1.5	140	1,660	19.9	4.9
18	7	45	0.4	0.6	113	761	6.9	4.0	345	2,990	27.0	5.8
20	101	578	3.5	7.2	202	2,265	13.6	27.3	2	8	0.1	28.0
22	4	7	0.1	0.1	42	222	0.7	0.7	291	4,760	14.3	14.3
Total	258	1,769	45.5	9.1	647	5,469	120.9	36.0	962	10.891	243.0	60.8

When considering alternating current for use in aircraft, frequency and number of phases as well as operating voltage must be decided. For the past five years the Army Air Corps has conducted a development program, during which frequencies of 60, 180, 240, 360, 400, and 800 cycles were considered. Equipment at frequencies of 360, 400, and 800 cycles was tested. It was found that the weight of such equipment as motors and transformers reaches a practicable minimum at approximately 240 cycles per second. The gain made by going to still higher frequencies is partially offset by the increase in iron necessary to decrease hysteresis losses. The selection of a suitable frequency, if the value is to be above 240 cycles, depends upon characteristics other than weight, the most important of which is the operating speed of alternators and generators. As noted, an operating speed of 24,000 rpm appears to be impracticable, for continuous-duty motors, but practicable for intermittent-duty motors. Therefore, the minimum frequency to be considered is 400 cycles. Tests with 400- and 800-cycle equipment showed little difference. However, the speeds available with 800 cycles are 48,000, 24,000, 16,000, 12,000, etc., to a practical minimum of 6,000 rpm. The speed for 400-cycle motors ranges from 24,000 to 3,000 rpm. As this appeared a more useful range of speed, the Army Air Corps has standardized on 400-cycle frequency for a-c power, in case it is used.

Tests also were made with both single- and three-phase systems. The single-phase system has the advantage that the distribution system requires only two cables, or one cable and a ground return. The three-phase system requires three smaller cables, or two and a ground return, and has the additional disadvantages that phases must be balanced within reasonable limits and that the power factor is lower. In so far as motor characteristics are concerned, a single-phase motor must use a split-phase winding supplied through a capacitor or resistor. The weight of this capacitor offsets the savings in wiring possible with the single-phase system. For reversing motors, the wiring system to a single-phase motor is actually heavier than that to a three-phase motor, since three large cables are used instead of three small ones.

The matter of paralleling the output of a-c accessory power plants is an important consideration, since the entire output of all accessory power plants must be available during certain conditions of flight. Parallel operation was not satisfactorily accomplished between single-phase alternators, while it was with three-phase alternators.

A-c aircraft power, in so far as military applications are concerned, has a doubtful status at the present time, due to the deficiencies in small engines for operation at altitude already mentioned. Since separate prime movers are impractical for use at high altitudes, the main engines on the airplane must be relied upon as a primary source of power. These engines must be operated at a variable speed, a condition which prevents any consideration of direct-driven alternators as a source of electric power. While it would be possible to utilize separate alternators with a divided bus to permit distribution of power from any alternator to any load, this installation would be more difficult than is desired. However, the successful development of a constant-speed drive which could be driven by the variable-speed main engine would permit the use of a-c power in medium and large aircraft. This constant-speed drive must be reasonably light in weight and of such accuracy that parallel operation between alternators can be obtained. To provide the equivalent of a battery for starting the main engines, an accessory power plant, to be used only on the ground for starting the main engines and for ground power, would be installed in each airplane.

One possible source of electric power not yet developed by the electrical industry is a variable-speed alternator operating with a rectifier to duplicate the present d-c generator. A 100-ampere 30-volt generator now weighs 32 pounds. The regulator and reverse current cutout used with this generator weigh another 4 pounds, making a total of 36 pounds. An equivalent variable-speed alternator and rectifier with controls in approximately this weight would have several advantages to justify its use. Voltage regulation would be a simpler matter, commutation would be eliminated, and radio interference would be reduced to an almost negligible amount.

Summarizing the situation with regard to electrical applications in aircraft, it is hoped that the electrical industry will take an increased interest in providing more suitable equipment to meet the special needs of the aviation industry.

Institute Activities

Attractive Features Arranged for Summer Convention at Toronto

THE AIEE summer convention, to be held in Toronto, Canada, June 16–20, 1941, offers members and guests unusual opportunities to combine business and pleasure. The technical program, which is scheduled to appear in the June issue, will include outstanding papers on a variety of timely subjects, as well as technical conferences and committee meetings. United States visitors, their Canadian hosts claim, will find novel touches in the entertainment, unusual opportunities to make their stay in Canada a high spot among long-to-be-remembered holidays. Sports and entertainment programs are now complete. Extensive plans have been made for the special benefit of women guests. Convention headquarters will be in the Royal York Hotel. No difficulties will be experienced in crossing the Canadian border (*EE, March '41, p. 134*).

Canadian AIEE members hope to make their guests feel so much at home that they will want to stay long after the convention is over, and return each year to renew acquaintances. The Mayor of Toronto, the Premier of Ontario, and the Prime Minister of Canada all have extended official and formal welcome to the AIEE. There remains, however, the unofficial and informal welcome for which Canada is noted.

For a city of over 850,000 population Toronto has exceptional facilities for enjoyment. Fourteen miles of lake front add an unusual summer-resort atmosphere to the service and comfort found only in large centers. At Sunnyside, one of the near-by beaches, is a most attractive amusement park. Closer still to convention headquarters are the Canadian National Exhibition grounds, 350 acres of landscaped park, and a mile and a half of Lake Ontario's waterfront. The exhibition buildings are now occupied by soldiers and airmen, but the grounds are open to visitors. Also near convention headquarters is old Fort York, built in 1793, a vivid reminder of the rivalries and contests of the past. Just two or three blocks from headquarters are two of the largest department stores in the world, as well as unusual specialty shops—always an attraction for women guests.

Only a few hours by train or automobile from Toronto in almost any direction will bring the visitor to vacation lands with clear sunlit waters and pine-fringed islands, where he may paddle a canoe, race a motor launch, sail a boat, or enjoy numerous steamer trips. Varied accommodations are available at hotels, camps, bungalows, or lodges. In the higher altitudes north of Toronto, hay fever is unknown.

East of Toronto, and reached by a beautiful drive along Lake Ontario, is the famous Thousand Island section of the St. Lawrence River. Just north of this are the picturesque Rideau Lakes. About 50 miles north of Toronto is Lake Simcoe. East of Lake Simcoe are the Kawartha Lakes and to the west is sheltered Georgian Bay with its many miles of sandy beaches and its surprisingly warm water. Another two-hour drive brings the vacation-bound visitor to the Muskoka Lakes and the Lake of Bays. Especially noted for fishing these districts also provide facilities for golf, tennis, swimming, and boating.

INSPECTION TRIPS

Advance registration for inspection trips is absolutely essential because of national-defense requirements. The trips committee has made strenuous efforts to provide a large variety of excursions.

Probably one of the most popular trips will be that scheduled for Thursday afternoon to the Toronto-Leaside 220-kv transformer station of the Hydro-Electric Commission of Ontario. Located on the outskirts of the city, some seven miles from convention headquarters, this is one of two receiving terminal stations of the Hydro's 220-kv system. The initial components of the station were placed in service in 1928,

Tentative Schedule of Events

Sunday, June 15

4:15 p.m.	English tea party

Monday, June 16

9:00 a.m.	Registration
9:30 a.m.	Instruments and measurements
9:30 a.m.	Communication
1:30 p.m.	Qualifying round for Mershon and Lee trophies
2:00 p.m.	Conference of officers, delegates, and members
9:00 p.m.	President's reception

Tuesday, June 17

9:00 a.m.	Registration
10:00 a.m.	Annual meeting
12:30 p.m.	Luncheon
1:30 p.m.	First round, Mershon trophy Second round, Lee trophy
2:00 p.m.	Conference of officers, delegates, and members (continued)
2:00 p.m.	Conference of Branch counselors
9:15 p.m.	Hart House party

Wednesday, June 18

9:00 a.m.	Registration
9:30 a.m.	Basic sciences and electronics
9:30 a.m.	Land transportation
9:30 a.m.	Switching equipment
12:30 p.m.	Board of directors' luncheon and meeting
1:30 p.m.	Second round, Mershon trophy
2:00 p.m.	Electrical machinery
2:00 p.m.	Relays, ligntning, and insulation

Thursday, June 19

10:00 a.m.	General session
10:30 a.m.	Semifinals, Mershon trophy
2:00 p.m.	Industrial power applications
2:00 p.m.	Power transmission
2:30 p.m.	Finals, Mershon trophy
7:30 p.m.	Annual dinner (summer formal)
9:00 p.m.	Dance (summer formal)

Friday, June 20

9:30 a.m.	Power generation
12:30 p.m.	Luncheon, presentation of sports prizes
2:00 p.m.	Conference on domestic and commercial applications
2:00 p.m.	Standards conference

Some Summer-Convention Attractions

Pictured on the facing page are some of the features in and near Toronto included in inspection-trip and entertainment plans.

1. Looking down the transformer runway, Toronto-Leaside station, at 420,000 kva of installed capacity

2. New Millwood Road residential substation of the Toronto Hydro-Electric System

3. Royal Canadian Yacht Club, Centre Island

4. Royal Ontario Museum, Toronto

5. Circuit breaker assembly, Canadian Westinghouse Company, Ltd.

6. Glengrove substation, Toronto Hydro-Electric System, 25,000 kva, supervisory controlled, is located in a residential district

7. Transformer banks at the rear of the Glengrove station

8. Unit substation, 26,400-volts, forming part of the primary network of the York Township Hydro-Electric System

9. Core and windings for a 25,000-kva outdoor transformer being lowered into the vacuum drying and oil-impregnation tank at the Toronto Davenport works of Canadian General Electric Company. The transformer will be installed in the new Burlington station of the Hydro-Electric Power Commission of Ontario


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Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held at the Royal York Hotel, Toronto, Ont., Canada, at 10 a.m. on Tuesday, June 17, 1941. This will constitute one session of the summer convention.

At this meeting, the annual report of the board of directors and the report of the committee of tellers on the ballots cast for the election of officers will be presented.

Such other business, if any, as properly may come before the annual meeting may be considered.

(*Signed*) H. H. Henline
National Secretary

since which time it has been expanded to its existing capacity of 420,000 kva. Three 220-kv circuits enter and one leaves the station, on four-circuit bridge-type structures on a 200-foot-wide right of way. Six banks of 45,000-kva and two banks of 75,000-kva three-winding transformers are installed. Four 25,000-kva vertical-shaft outdoor synchronous condensers also are installed.

Perhaps of still greater interest will be the Hydro-Electric Power Commission's new 220-kv receiving terminal now nearing completion of the initial installation. It is located some 40 miles west of Toronto on the Queen Elizabeth Way. Known as the Burlington transformer station, this new receiving terminal has an initial installation of two incoming 220-kv circuits and two banks of 75,000-kva forced air-cooled transformers. The station is designed for an ultimate installation of 450,000 kva. The 220-kv transmission extension of the Commission, around the metropolitan area of Toronto and west to Burlington, is of double-circuit construction, utilizing type *HH* segmental-copper conductors. Arrangements will be made to inspect this new construction as part of the Burlington trip.

For communications men, there will be a trip to the Bell Telephone automatic exchange and a specially arranged communications trip including radio station CBL, Hornby repeater station, and the Trans-Canada Airways beacon and airport facilities, both on Tuesday, June 17. A special trip for distribution men will include the low-voltage network of the Toronto Hydro-Electric System, also a tour of the recently completed primary network of York Township Hydro, as well as visits to a newly completed residential substation of the Toronto Hydro, and another to the Glengrove Avenue substation. A trip is also arranged to the Hillcrest shops of the Toronto Transportation Commission.

Of special interest also are organized trips to the Hydro-Electric Power Commission's laboratories, an inspection of the Commission's network calculator, and an evening trip (on Wednesday, June 18) to the Dunlap Observatory.

Efforts will be made to arrange trips to a number of manufacturing plants in Toronto, Hamilton, and Oshawa. These trips, of course, must be governed entirely by national-defense regulations in force at the time of the convention, but if advance registration indicates sufficient interest, the trips committee will try to arrange visits to such of the following plants as are of particular interest to visitors: Canada Wire and Cable Company, Ltd.; Canadian Westinghouse Company, Ltd.; Steel Company of Canada; Otis-Fensom Elevator Company; Ferranti Electric Company; Canadian General Electric Company, Ltd., transformer plant, and others.

ENTERTAINMENT

Members are urged to travel to Toronto over the week-end in order to attend the first get-together on Sunday afternoon. This will be an English-style tea party, to be held in the Palm Court of the Royal York Hotel, commencing at 4:15 p.m. The Royal York String Orchestra with additional artists will be in attendance. No charge will be made for attending members and their guests.

On Monday, June 16, the president's reception will be held at 9:00 p.m. in Room A of the Royal York, to be followed by an informal dance in the Concert Hall. As part of the entertainment after the dance, uniformed pipers will parade through the Concert Hall accompanied by dual flag bearers who will sing the British and United States national anthems. A buffet supper will be served at 11:30 p.m. Card playing will be arranged for in the anteroom. No charge will be made for the evening's entertainment.

On Tuesday, June 17, an organized luncheon is planned (tickets $1.00 each), to which women guests will be invited. At 9:15 Tuesday evening, members and guests will travel through the city to the University of Toronto's famous Hart House which has been turned over completely to the AIEE for the evening. Here a series of entertainment features will be presented from opening time until 12:30 a.m. Heading the list will be two stage performances in Hart House theater, one running from 9:30 p.m. to 10:15 p.m. and the other from 10:45 to 11:30. The Hart House carillon will be played by Leland Richardson during the period while guests are arriving. Several novel entertainment features will run concurrently with the main shows. The Toronto Dolphinettes will present a display of swimming and diving; a series of badminton games will be in progress in the upper gymnasium; a series of ten-minute musical recitals will be given in the music room; and other features are planned, including moving pictures presented by the Hydro-Electric Power Commission of Ontario, a marionette performance, and exhibition games of squash. There will be continuous dancing from 9:30 p.m. until 1:00 a.m. in the big gymnasium with an intermission during which Chinese performers will give the dragon dance. Weather permitting, those who prefer may wander out to the Quadrangle which will be suitably lighted. Tables and chairs will be placed there, under the open sky, punch will be served, and a trio of troubadours will be in attendance. A buffet supper will be served in the Great Hall. Tickets for the evening's entertainment will be $1.00 each.

The formal dinner and dance will be held in the Banquet Hall of the Royal York Hotel on Thursday, June 19. Tickets for the dinner are $1.50 each and for the dance $2.00. At 10:30 p.m. there will be an intermission of 15 minutes for a parade of a pipers' band in full-dress uniform, and other entertainment features. A buffet supper will be served at 11:30 p.m.

On Friday, June 20, there will be an organized luncheon in the Roof Garden, at which the sports prizes will be presented. Luncheon tickets will be $1.00 each.

SPORTS

Excellent facilities for practically all types of sport abound in and around Toronto. The term "golfers' paradise" has been applied to the city, and in addition there are ample facilities for tennis, aquatic sports, and many other types of outdoor activity. All golf events for men will be played at the Weston Golf and Country Club. Arrangements may be made with any member of the committee or at the registration desk for noncompetitive play on several other Toronto courses.

The qualifying round for the Mershon and Lee trophies will be played on Monday afternoon. The second 18-hole round for the Lee trophy will be played on Tuesday and in case of a tie an additional 18 holes will be played on Wednesday. The first round of match play for the Mershon trophy is to be played on Tuesday, the second round on Wednesday, and the third on Thursday morning, with the final round Thursday afternoon.

In addition to these annual competitions, there will be a District team competition in which each District may enter a team of four men. Then there is to be a "kicker's handicap" (blind bogey) event.

The Mershon tennis tournament for men will be played at the Boulevard Club on Toronto's lake shore, on the afternoons of June 16–19 from 2:00 to 5:30 p.m. The finals will be held on Thursday afternoon.

Women's golf events will be played at the Toronto Ladies' Golf and Country Club at Thornhill. Prizes will be provided for all competitions. Women wishing to compete should make their desire known at the women's committee desk at the time of registration. Courts will be available in the mornings at the Boulevard Club for women wishing to play tennis.

WOMEN'S ENTERTAINMENT

In planning entertainment the committee in charge assumed that women guests would prefer to have mornings relatively free to play golf or tennis, visit Toronto's shopping district, or follow other individual inclinations, without missing the prearranged events. The evening events are being held jointly for men and women. During the afternoons the following entertainment has been planned especially for the women and is complimentary to those wearing AIEE badges.

Monday, June 16. At 2:30 p.m., busses will leave the Royal York for a visit to the James Gardens in one of Toronto's fine residential suburbs, to be followed by a visit to the Old Mill tea gardens. The stone house on the F. T. James Estate stands on an escarpment overlooking the Humber Valley. In the natural sunken gardens, luxurious blue spruce trees form backgrounds for lawns and pools and exquisite flowers. Winding paths lead down through rock gardens and natural woods to the river. The Old Mill,

Some Toronto Hotels and Rates

Hotel	Single*	Double*	Single With Bath	Double With Bath
Royal York (headquarters)			$4.00	$6.00
King Edward			3.00 to $5.00	6.00 to $8.00
Prince George	$2.00	$3.00 to $3.50	2.50 to 3.00	4.00 to 5.00
Walker House	2.00	3.50	3.00	4.50 to 5.00

* Without bath but with running water.

where tea will be served, has a rich historical background. When the first white men came to Canada the Humber River was a well-known Indian pathway from Lake Huron to Lake Ontario. Today the ruins of the Old Mill, built on the Humber in 1798, can still be seen, and a visit to the Old Mill restaurant presents an opportunity for inspection of the many relics gathered together there.

Tuesday, June 17. Busses will leave the Royal York at 2:30 p.m. for Eaton's College Street store where a fashion show will be presented. Tea will be served, and may be followed by a tour through the store.

Wednesday, June 18. At 1:30 p.m., buses will leave the Royal York to take women guests to the Royal Canadian Yacht Club wharf, from where they will proceed by pinnace to the Royal Canadian Yacht Club on Toronto Island across the bay from the city. Those who wish may spend the afternoon at the Yacht Club for bridge and tea, and those not wishing to play bridge may enjoy a short launch cruise through the island lagoon.

Thursday, June 19. A conducted tour via the University of Toronto grounds and Parliament buildings to the Royal Ontario Museum, where they will be conducted through the sections in which they are especially interested. Because the Royal Ontario Museum is so vast (having five acres of galleries) it is impossible to see the whole museum in one attempt. Accordingly, to permit seeing the parts of most interest, guests will be urged to indicate their preference at the women's registration desk not later than Thursday morning. Included in the museum is a Chinese section, acknowledged to be one of the world's best, along with other sections devoted to pottery, dresses, furniture, gems, wild life in Canada, murals and panels illustrating the stages of the earth's evolution. Tea will be served in the garden.

HOTELS AND REGISTRATION

Members should make their hotel reservations by writing directly to the hotel preferred. For convenience, the rates of the headquarters hotel, the Royal York, and several other Toronto hotels are given in the accompanying table.

Members who will attend the convention should register in advance by filling in and mailing the advance registration card when received with the mailed announcement. This will assist the committee in making advance arrangements and minimizing congestion at the registration desk. A registration fee of $2.00 will be charged all nonmembers except Enrolled Students and the immediate families of members.

SUMMER CONVENTION COMMITTEE

M. J. McHenry, *chairman;* A. H. Frampton, *vice-chairman;* D. G. Geiger, *secretary;* C. E. McWilliam, *reasurer;* A. W. Bradt, C. H. Burchill, E. V. Caton, R. B. Chandler, K. V. Farmer, W. G. C. Gliddon, H. W. Haberl, G. R. Langley, J. H. Steede, and B. J. O. Strong. *Subcommittee chairmen:* M. J. McHenry, *finance;* T. W. Hill, *publicity;* W. J. Gilson, *entertainment;* T. W. Eadie, *sports;* J. F. Neild, *transportation;* V. G. Smith, *trips;* F. F. Ambuhl, *hotel and registration;* O. W. Titus, *women's entertainment;* J. W. Barker, *technical program;* O. W. Titus, *local representative, technical program;* M. S. Coover, *Sections;* and J. M. Thomson, *local representative, Sections.*

Pacific Coast Convention to Be Held at Yellowstone Park

The wonders of Yellowstone National Park will provide the setting for the AIEE Pacific Coast convention, to be held August 27–29, 1941. The Canyon Hotel, headquarters for the convention, is near the Great Falls of the Yellowstone, pictured on this page at the point where the canyon walls show the brilliant color that gave its name to Yellowstone Park, River, and Lake. The rocks are radioactive.

AIEE members and their families also may see Yellowstone's two groups of geysers and colored hot pools, and many miles of rugged scenery along paved safe highways. Along the roadside will be seen wild bear, pronghorn antelope, moose, elk, and deer. By going back farther, and having luck, the visitor may find beaver, buffalo, geese, mountain sheep, and rare swans. No fishing license is required in the Park, the streams of which are stocked afresh each year.

Especially for those driving to the convention, trips can be arranged to include rugged Glacier Park, several major hydroelectric plants, Fort Peck Dam, rodeos, Indian Reservations, little-known Morrison Cave (third largest in the United States), mines and smelters, and historical spots at Virginia City, Bannock, and several Indian battlefields. Further information may be obtained from the convention publicity chairman, Clair F. Bowman, Helena, Mont. Inspection trips will be announced in a subsequent issue. W. A. Boyer is chairman of that committee.

Future AIEE Meetings

Summer Convention
Toronto, Canada, June 16–20, 1941

Pacific Coast Convention
Yellowstone National Park, August 27–29, 1941

South West District Meeting
St. Louis, Mo., October 8–10, 1941

Southern District Meeting
New Orleans, La., December 3–5, 1941

Winter Convention
New York, N. Y., January 26–30, 1942

Methods of Mathematical Analysis to Be Published

"Advance Methods of Mathematical Analysis as Applied to Electrical Engineering" is the general title covering a symposium of five lectures given in New York between December 5, 1940, and April 2, 1941, under the sponsorship of the basic sciences group of the New York Section AIEE. Designed to acquaint the average engineer with the general principles (simplified and co-ordinated) involved, these lectures were received so enthusiastically that they currently are being developed into manuscript form for publication in ELECTRICAL ENGINEERING, perhaps beginning early this summer.

The following listing covers the intended subjects and authors:

1. Heaviside's Direct Operational Calculus, Professor J. B. Russell, Columbia University.
2. Integration in the Complex Plane, Professor Kurt O. Friedrichs, New York University.

3. Circuit Analysis by Laplacian Transforms, Doctor J. Millman, College of the City of New York.

4. Analysis of Systems by Fourier Integrals, Professor W. L. Sullivan, Stevens Institute of Technology.

5. Traveling Waves on Transmission Lines, Professor E. Weber, Polytechnic Institute of Brooklyn.

New Technical Committee Appointed

At its meeting January 30, 1941, the AIEE board of directors voted to establish a new technical committee on applications of electricity to therapeutics. The scope of the new committee will be decided upon by the members and the technical program committee, but in general it is planned to include all applications of electricity pertaining to health, such as sanitation, sterilization, and radiation.

Members of the new committee are:

Lloyd L. Call, *chairman*, General Electric X-Ray Corporation, 2012 Jackson Boulevard, Chicago, Ill., C. V. Aggers, W. D. Coolidge, Harvey Fletcher, Roy Kegerreis, and W. B. Kouwenhoven.

No Fortescue Fellowship for 1941–42

The Charles LeGeyt Fortescue Fellowship committee, meeting March 31, 1941, voted not to award the fellowship for the year 1941–42, "in view of the national emergency and the limited number of candidates making application." Announcement that applications were open appeared in the January issue, page 31.

The demand for young men in industry and military service resulting from the national emergency was considered by the committee to be the chief cause for the small number of applications received. The consideration that the funds of the fellowship might prove more valuable in helping young men readjust to normal industrial life at the end of the emergency also was a factor in the committee's decision to make no award for the present year.

Abstracts • • •

TECHNICAL PAPERS are previewed in this section as they become available in advance pamphlet form. Copies may be obtained by mail by remitting price indicated to the AIEE order department, 33 West 39th Street, New York, N. Y.; or at five cents less per copy if purchased at AIEE headquarters or at AIEE convention or District-meeting registration desks.

The papers previewed in this issue will be presented at the AIEE summer convention, Toronto, Canada, June 16–20, 1941.

Basic Sciences

41-96—Measurement of Prebreakdown Currents in Dielectrics With a Cathode-Ray Tube; *H. H. Race (F'39). 15 cents by mail.* In order to obtain more information regarding the mechanism of electrical breakdown in insulating liquids, a number of experimenters have studied current flow as a function of applied voltage, using high sensitivity d-c amplifiers with indicating instruments having relatively long time constants. Such instruments will not follow rapid changes in current where the time intervals are of the order of milliseconds or less. We investigated the possibility of using a cathode-ray tube as a current detector to follow current changes just preceding breakdown. This paper describes current measurements in liquids with 200-microsecond impulse voltage waves and current measurements in liquids and solids with gradually increasing unidirectional voltage applied to the specimens. In liquids, the evidence so far obtained leads to the tentative conclusion that the final breakdown current increases from a substantially steady value to failure in fractions of a microsecond. This indicates that the final breakdown mechanism is electronic. It appears also that the prebreakdown ionic current may be unrelated to the breakdown electronic current, since the breakdown gradient appears to be affected more by the electrode surface conditions than by the ionic conductivity of the liquid. In polystyrene and polyvinyl formal only one record was obtained showing any prebreakdown current greater than 10^{-8} amperes up to within 2 milliseconds of failure at breakdown gradients of the order of 2.5×10^{6} volts per centimeter.

41-103—A Short Method for Evaluating Determinants and Solving Systems of Linear Equations with Real or Complex Coefficients; *Prescott D. Crout. 20 cents by mail.* This paper describes without proof a short method for solving arbitrary systems of linear algebraic equations, and evaluating determinants, the quantities involved being either real or complex. The work consists largely in determining an "auxiliary matrix," or block of numbers, the process being particularly adapted for use with a computing machine. The setting down of this matrix and of the final results is the only writing required. The work is cut almost in half if the given equations (or determinant) are symmetrical. A "check column" may be used if desired. The method described is much shorter than Gauss' method even when there is symmetry and the coefficients are real, in which case Gauss' method has been considerably refined by Doolittle. (Gauss' method is much shorter than a solution by determinants.) The process is applicable to the general case of m equations in n unknowns.

Industrial Power Applications

41-99—A New Mercury Rheostatic Element for Regulation and Control; *K. A. Oplinger (M'39). 15 cents by mail.* This paper describes the principal design features and several typical applications of a new type of rheostatic device. The rheostatic member consists of a large number of hermetically sealed mercury contacts which can be operated by a small force and movement. A 100-step unit capable of controlling six kilowatts is described which is adaptable to many types of regulating systems. An electromagnetic driver operates the rheostatic member. Power amplification of the order of 100,000 can be obtained with the device.

Land Transportation

41-100—Glass-Bulb Mercury-Arc Rectifiers for Traction Service; *Charles E. Woolgar. 15 cents by mail.* The paper gives a general survey of the ability of glass-bulb mercury-arc rectifiers satisfactorily to meet the stringent requirements of traction service. Major features pertaining directly to glass bulbs are discussed, such as plant capacity, maintenance, efficiency, robustness, etc., but no attempt is made to include wider problems common to mercury-arc rectifiers as a class. Wherever necessary, comparison has been made to characteristics and behavior of other types of conversion equipment to indicate in what degree glass-bulb rectifiers meet the special requirements of traction service. Typical glass-bulb rectifier ratings, for example, efficiency, power factor, regulation, and overload capacity have been given without comment, while ability to handle severe short circuits, stability, robustness, and ability to operate in parallel with other equipments is discussed in more detail. The paper indicates clearly that glass-bulb rectifiers are suitable for traction service and in some respects show to advantage over other types of conversion equipment, particularly in the multiunit construction, lack of troublesome auxiliaries, high over-all efficiency, reliability, negligible maintenance costs, and flexibility.

41-101—Electric Locomotive Application; *E. W. Brandenstein (M'37) and D. R.*

Membership—

Mr. Institute Member:

For the eight-month period ending March 31, we have received 1,627 new applications for membership, compared with 1,573 for the same period of last year. This is good and we appreciate your help.

However, only 852 applications were received in this period from Enrolled Students, as compared with 883 for same period last year. We need your help in locating and bringing the advantages of membership to these young engineers. Co-operation with your Section membership committee in this matter will be appreciated.

O. C. Brill

Chairman, National Membership Committee

MacLeod (*A'33*). *20 cents by mail.* An electric locomotive of balanced design suitable for high-speed service, either passenger or freight, is a modern development in railroad motive power. This paper presents curves which show how high horsepower at speed can supplement momentum operation to haul heavy trains over difficult profiles. The characteristics of the principal parts of electric locomotives are discussed, and the engineering fundamentals which enter into their selection are outlined. The conclusion is drawn that the electric locomotive is capable of moving more gross ton miles per train hour with fewer units than any other type of motive power.

Power Transmission and Distribution

41-94—Conductor Vibration—the Theory of Torsional Dampers; *James W. Speight. 20 cents by mail.* The paper is a theoretical treatment of the torsional damper which has been applied effectively on transmission-line conductors for the suppression of æolian vibrations. The formulas of the energy dissipation are derived for three cases: a single rigid damper, two rigid dampers at one end of a span, and a single damper with a resilient joint at the center of gravity. The results are valuable in understanding the mode of operation of the torsional damper and point to certain optimum features of design. The formulas can be used for numerical calculations, if the requisite physical constants are known.

41-97—Measurement and Control of Conductor Vibration; *Gordon B. Tebo* (*A'36*). *20 cents by mail.* A method is outlined for determining the effectiveness of devices used for preventing vibration fatigue in transmission conductors. Measuring equipment described provides field records of conductor vibration in the quantitative form essential for such determinations. Records obtained on typical constructions are analyzed and correlated with fatigue tests and operating experience to determine the probable life of the conductor. Data are given on the performance of various devices, including a special loose-core conductor, a double-suspension clamp, armor rods, Stockbridge dampers, and a newly developed torsional damper. Of the devices tested, dampers are shown to be most effective in reducing vibration stresses.

41-95—The 220,000-Volt System of the Hydro-Electric Power Commission of Ontario—II; *A. H. Frampton* (*M'28*) *and E. M. Wood* (*M'25*). *20 cents by mail.* At the summer convention of the Institute in 1930 Mr. E. T. J. Brandon presented a paper under this same title, describing the design of the initial components of this system, which had then been in operation approximately one and one-half years. At that time, one and one-half circuits, having a combined length of 350 miles, were in service, transmitting approximately 150,000 horsepower to a receiving terminal station in the Toronto area of 180,000-kva capacity. At the present time, the Commission is operating a total of 1,000 miles of single-circuit 220,000-volt construction, with one receiving terminal of 420,000-kva rated capacity, and is placing into service immediately 45 miles of double-circuit construction and a second receiving terminal of 150,000-kva capacity. This paper presents a brief history of the development of the system and places on record the experience gained in 8,400 circuit-mile-years of operation of the transmission circuits. Data are presented regarding lightning outages and the behavior of the circuits under sleet and conductor vibration. These data are then used to indicate the reasons for certain revisions made in the design of new single-circuit construction carried out during 1940–41, and to indicate the factors that influenced the design of a new 45-mile double-circuit extension. The paper concludes with a discussion of the relay protection system and the improvements now being incorporated therein.

Protective Devices

41-102—Development in Lightning Protection of Stations; *E. R. Whitehead* (*M'39*). *15 cents by mail.* Effective direct-stroke lightning protection for high-voltage high-capacity stations can be obtained by the use of the overhead ground wire, transformer-mounted arresters, and line entrance back-up gaps or protective tubes. For stations on subtransmission systems employing wood insulation throughout, overhead ground wires are usually not economical, and lightning strokes having high rates of current rise may cause either arrester or transformer failures. A reactor can be employed to compensate for the "turn-up" of the gap or tube flashover characteristic, and provide a high degree of direct-stroke protection for the transformer winding.

41-100—Field Investigations of Lightning; *C. F. Wagner* (*F'40*), *G. D. McCann* (*A'38*), *and Edward Beck* (*M'35*). *25 cents by mail.* During the past two years lightning investigations have been carried out by the Westinghouse company by means of specially devised instruments, chief of which is the fulchronograph. The stations at which these instruments are located are of two kinds; first, those designed to measure the total current in direct strokes, and second, power system stations designed principally to measure the discharge currents in protective devices. Considerable information has been obtained regarding the multiple character and wave shape of the current in the discharges for both types of stations. These data, in conjunction with other data on the field performance of arresters, have revealed definite differences between the nature of direct strokes and the currents they produce in arresters. They also show that the nature of the system grounding affects the character of the currents discharged by arresters.

41-99—Bus Protection Independent of Current Transformer Characteristics; *G. Steeb* (*M'34*). *15 cents by mail.* Reliable high-speed bus protection can now be provided by a method which requires neither matched current transformers nor the insulation of all equipment from ground. Standard-made, high-speed, directional and plunger-type relays of simple design provide the basic means of bus protection. A salient feature of this scheme is that false tripping, because of defects in its circuits or mistakes made by maintenance men, is very unlikely.

Standards • • •

Co-ordinating Committee 7 Establishes Subcommittee

A subcommittee of standards co-ordinating committee 7, on conduction in vacuum and low-pressure gases and vapors, has been organized under the chairmanship of Thomas Spooner, manager of the engineering laboratories and standards department of the Westinghouse Electric and Manufacturing Company. This subcommittee will carry on, within its assigned scope, the usual activities of the co-ordinating committees. More specifically, it will attempt to work out guiding standards relating to devices which depend in their operation upon conduction in vacuum and low-pressure gases and vapors, as was done for machines, transformers, etc in AIEE Standard No. 1. One of the first tasks will be to classify the various types of vacuum and gas-conductivity devices according to basic principles of operation, structural features, and utility; also, to correlate, supplement, and bring up to date existing definitions as proposed by various standardizing bodies.

Apparatus Bushings. A proposed AIEE Standard on Apparatus Bushings, No. 21, is now available in pamphlet form. This has been issued for trial use. It was developed by the joint committee on bushing standardization working under the chairmanship of R. T. Henry. These proposed standards specifically cover the following types of bushings: outdoor bushings for large apparatus; cover-type bushings for small apparatus; and indoor bushings for all types of apparatus except dry-type instrument transformers, air-blast transformers, dry-type regulators, and circuit breakers rated below 5,000 volts, and nonoiltight oil circuit breakers rated 50,000 kva or less. An appendix to the standard contains a test code and the bushing requirements as specified in the standard apply to bushings when mounted for testing in accordance with the specified arrangements as given in the code. Copies of No. 21 can be obtained without charge by addressing AIEE headquarters, 33 West 39th Street, New York, N. Y.

Abbreviations for Scientific and Engineering Terms. An American Standard for Abbreviations for Scientific and Engineering Terms, *Z*10.1, has just been issued. This is a revision of the American Tentative Standard published in 1932. It was developed by a subcommittee of the Sectional Committee on Letter Symbols and Abbreviations for Science and Engineering. G. A. Stetson, editor of *Mechanical Engineering* was chairman of the subcommittee. Copies of *Z*10.1 can be obtained at a cost of 35 cents each by addressing American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

Personal • • •

R. E. Doherty (A'16, F'39) president of Carnegie Institute of Technology, Pittsburgh, Pa., has been appointed chairman of the Production Planning Board, recently created as an agency of the Office of Production Management to formulate a long-range program for defense and post-emergency production. Doctor Doherty's appointment as a charter member of the board was announced in the April issue, page 182. Born January 22, 1885, at Clay City, Ill., he received the degree of bachelor of science from the University of Illinois in 1909, that of master of science from Union College in 1920, and the honorary degrees of master of arts, 1931, from Yale University, and doctor of laws, from Tufts College and the University of Pittsburgh, 1936. He was employed as a student engineer by the General Electric Company, Schenectady, N. Y., in 1909, and in 1910 became designing engineer on a-c machinery. He later became assistant to the late C. P. Steinmetz (A'90, F'12) and in 1922 was appointed consulting engineer. He organized the company's advanced course in engineering and was responsible for educational work among college graduates in General Electric employ. In 1931 he was appointed professor of electrical engineering at Yale University and in 1933 became dean of the school of engineering. He has been president of Carnegie Institute of Technology since 1936. He was elected chairman of the Engineers Council for Professional Development in 1940, having served as vice-chairman 1938–39. The recipient of the 1937 Lamme Medal of the AIEE, Doctor Doherty has been active on various Institute committees. He is also a member of the Society for Promotion of Engineering Education, Tau Beta Pi, Sigma Xi, and Eta Kappa Nu, and is the author of many technical and general articles.

T. F. Ball (M'28, F'38) formerly professor and head of the department of electrical engineering, University of South Carolina, Columbia, S. C., has been appointed professor of electrical engineering at the United States Naval Academy, Annapolis, Md. He has received a commission as lieutenant commander in the Naval Reserve. Born at Richmond, Va., April 18, 1894, he received the degrees of bachelor of science (1915) from the University of South Carolina and master of science (1919) from the University of Virginia. He was instructor in physics at the University of South Carolina 1915–16, and at the University of Virginia 1916–17, and assistant professor of physics at the latter institution 1919–22. He returned to the University of South Carolina as associate professor of electrical engineering in 1925, and has been professor and head of the department since 1928. He has also carried on active practice as a consulting engineer during this period, and in 1933 was chairman of the Water Power Investigating Committee for the State of South Carolina. He was active in the formation of the AIEE South Carolina Section in 1940 and was elected its first chairman, and has been counselor for the University of South Carolina Branch since 1928. He is also a member of the American Association for the Advancement of Science and the Society for Promotion of Engineering Education.

J. W. Barker (M'26, F'30) dean of engineering, Columbia University, New York, N. Y., has been appointed special assistant to the Undersecretary of the Navy, Washington, D. C. Dean Barker, who is currently serving the Institute as vice-president of District 3 and chairman of the technical program committee and committee on award of Institute prizes, has a distinguished record of professional service. A native (1891) of Lawrence, Mass., he received the degrees of bachelor of science (1916) and master of science (1925) from Massachusetts Institute of Technology, Cambridge, where he was associate professor of electrical engineering 1925–29. From 1916 to 1925 he served in the Coast Artillery Corps of the United States Army, for a time as officer in charge of civil affairs for the American forces in Germany. He headed the department of electrical engineering at Lehigh University, Bethlehem, Pa., 1929–30, and since 1930 has held his position at Columbia. He has been active on Institute committees and in other technical societies and was recently elected to the executive committee of the council of the American Association for the Advancement of Science (*EE, Feb. '41, p. 87*).

K. W. Waterson (A'05, F'22) has retired as vice-president in charge of personnel relations, American Telephone and Telegraph Company, New York, N. Y. Born March 9, 1876, at Chelsea, Vt., he received the degree of bachelor of science in electrical engineering at Massachusetts Institute of Technology in 1898. He entered the employ of American Bell Telephone Company, AT&T predecessor, in Boston, Mass., immediately after graduation, in 1905 was placed in charge of traffic engineering, and in 1906 in charge of both traffic and central-office engineering. Upon reorganization of the engineering department in 1909 he was made engineer of traffic, and in 1919 was placed in charge of the department of development and research, continuing to head the traffic-engineering section of the engineering department. In 1920 he was made assistant chief engineer of the department of operation and engineering, and in 1927 assistant vice-president. He has been vice-president in charge of personnel relations since 1937. He also resigns as a director of Bell Telephone Laboratories, Inc.

John Morse (A'09) formerly assistant general manager, Shawinigan Water and Power Company, Montreal, Quebec, Canada, has been appointed vice-president in charge of operation. He was born February 20, 1881, at Sjurberg, Rattvik, Sweden. After working as a draftsman for the Maxwell-Briscoe Motor Company, Tarrytown, N. Y., and for General Electric Company, Schenectady, 1906–07, he was employed by the Shawinigan company in 1907 and has been associated with the company continuously since as draftsman, superintendent of operation, general superintendent, and assistant general manager. He is chairman of the national Canadian committee of the International Conference on High-Voltage Electrical Systems (CIGRE), past president of the Canadian Electrical Association, and also a member of the Engineering Institute of Canada.

A. R. Rutter (A'35) has been appointed manager of engineering, meter division, Westinghouse Electric and Manufacturing Company, Newark, N. J. A native (1894) of Wellsburg, W. Va., he received the degree of bachelor of science in electrical engineering from the University of Pittsburgh in 1917. After working for a short time for the Duquesne Light Company, Pittsburgh, Pa., and the Pittsburgh Experiment Station of the United States Bureau of Mines, he was employed in the engineering department of the Westinghouse company at East Pittsburgh. He was made section engineer in the meter division when the division was transferred to Newark, N. J., in 1928, and a few months ago was appointed assistant manager of the engineering department of the division (*EE, April '41, p. 182*).

L. H. Hill (A'22, F'38) formerly engineer in charge of transformer division, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been made assistant manager of the company's electrical department. After receiving the degree of electrical engineer from Cornell University in 1922, he entered the transformer engineering department of the Westinghouse Electric and Manufacturing Company, and was placed in charge of power transformer development in 1925. He became manager of the transformer division of the American Brown Boveri Company, Camden, N. J., in 1928, and continued in that position after Allis-Chalmers took over the company in 1931.

E. S. Webster (A'91, M'07) co-founder of the firm of Stone and Webster, Inc., Boston, Mass., has been elected chairman of the board. The office of vice-chairman, formerly held by Mr. Webster, has been eliminated. Mr. Webster was born August 26, 1867, at Boston, Mass., and received the degree of bachelor of science from Massachusetts Institute of Technology in the electrical-engineering course in 1888. In 1889 he formed with the late C. A. Stone (A'91, M'07) the engineering firm of Stone and Webster, which he headed jointly with Mr. Stone until the latter's recent death (*EE, April '41, p. 183*).

G. B. Shanklin (A'16, M'29) application engineer, central station department, General Electric Company, Schenectady, N. Y., has received a Charles A. Coffin award for the development of a low-voltage gas-pressure cable. This is his second Coffin award, the first having been presented in 1932 for improvements in installation of oil-filled cable. Mr. Shanklin has been with General Electric since graduating from the University of Kentucky with the degree of bachelor of mechanical engineering in 1911, and has been with the central station department since 1922.

H. J. Klumb (A'16) formerly assistant superintendent of electrical distribution, Rochester, N. Y., Gas and Electric Corporation, has been made superintendent of electrical distribution. He received the degree of bachelor of science in electrical engineering from

Mississippi Agricultural and Mechanical College in 1912, and after four years with the Westinghouse Electric and Manufacturing Company, was employed in the meter department of the Rochester Railway and Light Company, predecessor of the present company, in 1916.

W. R. LaMotte (M'36) formerly superintendent of the Essex generating station of the Public Service Electric and Gas Company, Newark, N. J., has been appointed assistant general superintendent of generation, general office, a newly created position. A graduate of Clemson College (1912), he has been associated with the company and its predecessors since 1914, except for service in the United States Navy, 1917–18, and has been superintendent of the Essex station since 1926.

J. F. Calvert (A'27, M'35) professor and chairman of the department of electrical engineering, Northwestern Technological Institute, Evanston, Ill., has been appointed a civilian employee of the United States Navy, with headquarters at Washington, D. C. **E. W. Kimbark** (A'27, M'35) assistant professor of electrical engineering, has been made acting chairman of the department for the period of Chairman Calvert's absence.

R. C. Giese (A'19, M'32) formerly district plant superintendent, American Telephone and Telegraph Company, Springfield, Ill., has been appointed division plant superintendent, division 1, long lines department, New York, N. Y. **H. H. Nance** (M'24), plant extension engineer, has been appointed engineer, long lines department, and **J. E. Dingman** (M'37) formerly division plant superintendent, division 7, becomes plant extension engineer.

H. B. McIntyre (M'38) formerly general commercial engineering assistant, New England Telephone and Telegraph Company, Boston, Mass., has been appointed general commercial toll-rate engineer. He entered the telephone business in 1922 in Manchester, N. H., becoming division commercial engineer of the southern division of the New England company in 1926, rate engineer of the southern area in 1929, and assuming his former position in 1935.

F. J. Chesterman (A'20, F'22) vice-president and general manager, western division, Bell Telephone Company of Pennsylvania, Pittsburgh, Pa., has been made vice-president in charge of operations, with headquarters at Philadelphia. He has been associated with the Bell System since 1905, going to the Pennsylvania company in 1920 as chief engineer, and being appointed vice-president and general manager of the western division in 1926.

Alexander Wilson, 3d (A'15) formerly manager, electric operations department, Philadelphia Electric Company, Philadelphia, Pa., has been appointed manager of the company's newly formed transmission and distribution department. **G. S. Van Antwerp** (A'25) formerly general superintendent of electric transmission and distribution, continues as general superintendent of the new department.

G. C. Tenney (A'35) editor, *Electrical West*, McGraw-Hill Company of California, San Francisco, recently was elected treasurer of the Northern California Electrical Bureau. **W. P. L'Hommedieu** (M'38) manager, central station sales, Pacific Coast district, Westinghouse Electric and Manufacturing Company, San Francisco, was elected a member of the executive committee of the bureau.

P. L. Giering (A'26, M'31) former chief electrical engineer, New York World's Fair, New York, N. Y., has been appointed chief electrical engineer, Caribbean Architect-Engineer, New York, N. Y. A graduate of Rensselaer Polytechnic Institute, he has practiced as consulting electrical engineer, having worked on the Detroit and Boston vehicular tunnels, and other projects.

C. F. Craig (M'27) vice-president, American Telephone and Telegraph Company, New York, N. Y., has been placed in charge of the personnel relations department of the company. He had been head of the long lines department since his election as vice-president in 1940. A biographical sketch of Mr. Craig appeared in the August 1940 issue, page 344.

H. P. Sedwick (M'32) general manager, Public Service Company of Northern Illinois, Chicago, Ill., has been elected vice-president of the company. He will continue as general manager. A biographical sketch of Mr. Sedwick appeared in the May 1940 issue, page 216.

A. A. Schuhler (A'19, M'27) formerly protection engineer in charge of government division, American District Telegraph Company, Washington, D. C., is now employed as sales manager, Schwarze Electric Company, Adrain, Mich.

G. L. Oscarson (A'24, M'30) formerly sales manager, St. Louis (Mo.) district, Electric Machinery Manufacturing Company, Minneapolis, Minn., has been appointed chief application engineer of the company, with which he has been associated since 1922.

W. E. Poor (A'15) vice-president, Hygrade-Sylvania Corporation, Salem, Mass., has been made executive vice-president in charge of all operations of the company, with headquarters at New York, N. Y. He has been with the company since 1910.

Eric O'Hara (A'36) sales engineer, Cincinnati Gas and Electric Company, Cincinnati, Ohio, has been elected president of the Technical and Scientific Societies Council of Cincinnati for the year beginning March 1, 1941.

J. R. Charlton (A'22, M'29) formerly division plant engineer, American Telephone and Telegraph Company, St. Louis, Mo., has been appointed area plant supervisor, southern area, with headquarters at Atlanta, Ga.

O. C. Schlemmer (A'30, M'39) formerly plant supervisor, Cincinnati and Suburban Telephone Company, Cincinnati, Ohio, has been transferred to the personnel relations department, American Telephone and Telegraph Company, New York, N. Y.

J. A. Powell (M'31) formerly vice-president, Utility Management Corporation, Reading, Pa., has become associated with Stone and Webster Engineering Corporation, with headquarters at Boston, Mass.

R. R. Wisner (A'23) electrical engineer, Stone and Webster Engineering Corporation, Boston, Mass., has been appointed assistant chief electrical engineer. He has been with Stone and Webster since 1912.

L. D. Canfield (A'21) formerly vice-president and general manager, Westinghouse X-Ray Company, Long Island City, N. Y., has been appointed manager of the X-ray division.

J. O. Walz (A'21) formerly section engineer, small motors division, Westinghouse Electric and Manufacturing Company, Lima, Ohio, has been made manager of the engineering department of that division.

C. E. Mason (A'34) general plant supervisor, Indiana Bell Telephone Company, Indianapolis, has also been given the duties of general plant employment supervisor for that company.

Obituary • • •

John Henry Schumacher (A'07, M'13) president, Schumacher-Mackenzie, Ltd., contracting electrical engineers, Winnipeg, Manitoba, Canada, died April 1, 1941. He was born March 6, 1880, at Dubuque, Iowa, and received the degree of electrical engineer from the University of Minnesota in 1903. From 1903 to 1907 he was employed by W. I. Gray and Company, contracting engineers, Minneapolis, Minn., as journeyman electrician and later as assistant superintendent and superintendent. In 1908 he was construction manager for the Minneapolis Electric Equipment Company, and in 1909 went with the Charles L. Pillsbury Company, consulting engineers. He went to Winnipeg in 1911 as manager and engineer of the Mitchell-Gray Electric Company. When the company was reorganized in 1913 as the Schumacher-Gray Company, Ltd., the became treasurer and manager, later becoming president of the firm, which subsequently became Schumacher-Mackenzie, Ltd. Although continuing as president, he retired from active business in 1935. He was vice-president of the Electrical Heating Company, Ltd. and the Power and Mine Supply Company. He was also a member of the Illuminating Engineering Society, Engineering Institute of Canada, Sigma Xi, and Tau Beta Pi, western Canada committeeman for the National Electrical Contractors Association, and was active in local electrical organizations in Winnipeg.

Frederick Valdemar Henshaw (A'89, M'95) financial consultant, Wood, Struthers, and Company, New York, N. Y., died March 23, 1941. He was born August 9, 1866, at Brooklyn, N. Y., and studied at Bishops College, Montreal, Quebec, Canada, where he was for a time assistant to the professor of chemistry. He was with Evans Brothers

and Mason, Ltd., chemical works, 1885–86; in 1887 was employed by the Royal Electric Company, Montreal manufacturers of Thomson-Houston machinery; and in 1888 became design engineer for the C. and C. Electric Company, Brooklyn, N. Y. He was later employed as erecting engineer by the Crocker-Wheeler Company, Ampere, N. J., and for many years was engaged in private consulting practice in New York, N. Y. Before the World War he was employed by General Electric Company and made several trips abroad to appraise properties. He was associated for a time with Bonbright and Company, utility investment firm, and in 1922 joined Wood, Struthers, and Company as consultant. He was instrumental in drafting the bill passed by the New York State Legislature in 1927 which permitted savings banks to invest in utility bonds. He was also a member of The American Society of Mechanical Engineers.

Archibald Kane MacNaughton (A'21, M'26, F'37) distribution betterment engineer, Ebasco Services, Inc., died in March 1941 at Atlanta, Ga. He was born January 21, 1894, at Calumet, Mich., and studied electrical engineering at the University of Michigan. In 1916 he was employed in the meter department of the El Paso, Tex., Railway, Light, and Power Company, the first of several companies under Stone and Webster management with which he was associated. He became secretary to the manager in 1917. In 1918 he was made general superintendent of the Ponce, Puerto Rico, Railway and Light Company, and in 1920 went to the Blackstone Valley Gas and Electric Company, Pawtucket, R. I., as electrical engineer, later becoming superintendent of distribution. He served as electrical engineer for Stone and Webster, Inc., Boston, Mass., 1926–27, and for the Narragansett Electric Company, Providence, R. I., 1927–28. From 1928 to 1932 he was planning engineer for the Georgia Power Company, Atlanta, and from 1932 to 1938 supervising engineer for the Commonwealth and Southern Corporation at Birmingham, Ala. He had been with Ebasco Services since 1938.

George W. Whittemore (A'02) retired assistant vice-president, New York, N. Y., Telephone Company, died August 22, 1940, according to information just received. He was born December 14, 1868, in Brooklyn, N. Y., and received the degree of bachelor of arts from Columbia University in 1890, later taking graduate work in electrical engineering at Columbia and a law course at the New York Law School. He entered the long lines department of the American Telephone and Telegraph Company in 1892, and in 1899 was transferred to the Bell Telephone Company of Buffalo, N. Y., as engineer, becoming general superintendent of plant in 1902. He was appointed chief engineer of the New York Telephone Company in 1910 and in 1916 became assistant chief engineer for a group of eastern companies in the Bell System, including the New York company. He had charge of preparing the New York Telephone Company's valuation of property for Federal rate hearings in 1924, and in 1927 was appointed assistant vice-president in charge of appraisals, depreciation studies, and rate case matters. He retired in 1934.

Thomas Smith Baker (A'28, M'38) radio engineer, Tropical Radio Telegraph Company, Boston, Mass., died February 27, 1941, at Washington, D. C. He was born July 24, 1896, at Sullivan, Maine, and took the Navy electrical and radio course at the University of Washington. He was an apprentice electrician in the United States Navy 1914–17, and radio electrician in the Naval Reserve 1917–19. In 1920 he became shift engineer for the Radio Corporation of America, at Bolinas, Calif., and returned to that organization in 1928 after several years on electrical construction work for Pacific Gas and Electric Company, Yosemite Portland Cement Company, and General Electric Company. In 1930 he went with Press Wireless, Inc., Chicago, Ill., and was chief engineer 1932–36. He was superintendent of radio construction, Office of the Chief Signal Officer, United States Signal Corps, Washington, D. C., 1936–37; chief engineer, communications division, Hearst Radio, Inc., New York, N. Y., 1937–39; and had since been traveling engineer for Tropical Radio Telegraph Company in Panama.

Herbert Monroe Case (A'11, F'38) consulting engineer, Long Island Lighting Company, New York, N. Y., died at Amityville, N. Y., March 31, 1941. He was born at Hartford, Conn., September 29, 1875, and received the degree of bachelor of science in electrical engineering at Massachusetts Institute of Technology in 1899. The same year he was employed by the General Electric Company, first on installations at Boston, Mass., then in the testing department at Schenectady, N. Y. He was transferred to Cincinnati, Ohio, as sales engineer about 1902. In 1905 he became consulting engineer for the General Engineering Company, Cleveland, Ohio, and two years later manager of the Connersville, Ind., Light, Heat, and Power Company. He returned to General Electric in 1910 as engineering specialist with the New York, N. Y., office. In 1912 he became vice-president and chief engineer of E. L. Phillips and Company, New York, continuing in this position until 1933, when he became associated with the affiliated Long Island Lighting Company.

John F. Mulligan (A'29, M'37) general superintendent, electric distribution construction, Consolidated Edison Company of New York, Inc., New York, N. Y., died February 6, 1941. He was born March 1, 1881, at Rock Tavern, N. Y., and studied at the College of the City of New York. He was employed by the United Electric Light and Power Company, one of the predecessors of Consolidated Edison, in 1902. In 1911 he was appointed assistant foreman, in 1918 district foreman, in 1922 general foreman, and in 1923 assistant superintendent of the cable bureau. In 1930 he became assistant superintendent of the transmission and distribution department of the United company, and in 1933 supervisor of the transmission bureau of that and the New York Edison Company. He became superintendent of transmission and distribution for New York Edison the same year, and continued in that position with Consolidated Edison until the beginning of 1941, when he became general superintendent of the electric distribution construction department.

Henry Carter Don Carlos (F'18) chief operating engineer, Hydro-Electric Power Commission of Ontario, Toronto, Ontario, Canada, died March 29, 1941. He was born in Moniteau County, Mo., November 13, 1875, and received the degree of bachelor of science in electrical engineering from the University of Missouri in 1902. From 1902 to 1905 he was electrical engineer for the Telluride Power Company, Telluride, Colo., and from 1905 to 1912 superintendent of the Eureka, Utah, Electric Company. During the latter period he was in charge of distribution and transmission for both companies. He had been chief operating engineer of the Ontario Hydro-Electric Power Commission since 1912, in charge of operation and maintenance of all generating stations, substations, and transmission lines. He was a director of the Institute 1926–30, chairman of the Toronto Section 1924–25, and past president of the Engineers Club of Toronto.

Frank Llewellyn Moser (A'25, M'31) superintendent of maintenance, Duke Power Company, Charlotte, N. C., died March 25, 1941. He was born October 7, 1882, China Grove, N. C., and attended Lenoir College. After four years in the United States Navy he was employed in 1905 in the construction and maintenance department of the Southern Power Company, a predecessor of Duke Power Company. In 1913 he became superintendent of maintenance, in charge of installation and maintenance of all electrical apparatus, and continued in that position until the time of his death.

Harry A. Ward (A'35) foreman of generator repairs, Interborough Rapid Transit Company, New York, N. Y., died recently. He was born at New York, N. Y., December 3, 1886, and educated there. From 1901 to 1903 he was employed by the Charles A. Borne Company, on motor and generator repairs, and during the next two years by the Westinghouse Electric and Manufacturing Company, on construction of a-c generators. He had been with the Interborough Rapid Transit Company since 1905, becoming assistant foreman of armature repairs in 1915, and foreman of generator repairs in 1932.

Membership

Recommended for Transfer

The board of examiners, at its meeting on April 17, 1941, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Hibshman, N. S., associate professor of electrical engineering, Lehigh University, Bethlehem, Pa.
Hudson, Ralph G., professor of electrical engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Spracklen, Emery E., superintendent, transmission and distribution, The Empire District Electric Company, Joplin, Mo.
Wagner, Walter C., general superintendent, meter division, Philadelphia Electric Company, Philadelphia, Pa.

4 to Grade of Fellow

To Grade of Member

Birchard, W. E., electrical engineer, General Electric Company, Pittsfield, Mass.
Bodine, H. Keith, assistant chief draftsman, Philadelphia Electric Company, Philadelphia, Pa.
Curtis, Hubert C., president, The Curtis Development and Manufacturing Company, Milwaukee, Wis.
Dalgleish, R. H., chief engineer, Capital Transit Company, Washington, D. C.
Ekvall, H. N., engineer, Philadelphia Electric Company, Philadelphia, Pa.
Jones, F. S., chief engineer, Socony Vacuum Oil Company, Inc., Boston, Mass.
Langguth, P. O., assistant manager, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Lingal, H. J., engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Lovelace, C. K., chief electrician, Oklahoma Gas and Electric Company, Enid, Okla.
Manspeaker, E. D., sales engineer, General Electric Company, Jackson, Mich.
Metz, H. E., electrical engineer, Landers, Frary and Clark, New Britain, Conn.
Oliver, J. H., assistant managing engineer, General Electric Company, Philadelphia, Pa.
Reeves, H. J., consulting engineer, H. Jack Reeves, Spokane, Wash.
Rittenhouse, L. H., professor in charge of engineering, Haverford College, Haverford, Pa.
Rudrow, R. G., electrical engineer, Atlas Powder Company, Wilmington, Del.
Schmidt, W. C., transmission line engineer, Commonwealth and Southern Corporation, Jackson, Mich.
Shawver, J. W., assistant superintendent, Oklahoma Gas and Electric Company, Oklahoma City.
Swiedom, K. L., relay engineer, West Texas Utilities Company, Abilene, Tex.
Ziev, Meyer, assistant electrical engineer, United States Navy Yard, Philadelphia, Pa.

19 to Grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical Districts. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before May 31, 1941, or July 31, 1941 if the applicant resides outside of the United States or Canada.

United States and Canada

1. North Eastern

Amato, J. P., Hartford Electric Light Company, Hartford, Conn.
Cramer, T. A., General Electric Company, Schenectady, N. Y.
Crosby, S. P., General Electric Company, Lynn Mass.
Emigh, W. F., General Electric Company, Lynn, Mass.
Erskine, H. E. (Member), United States Government, Fort Devens, Mass. (re-election).
Kaufmann, R. H. (Member), General Electric Company, Schenectady, N. Y.
Klodinski, E. J., Eastman Kodak Company, Rochester, N. Y.
Lees, W. J., Eastman Kodak Company, Rochester, N. Y.
Lind, O. I., Norton Company, Worcester, Mass.
Mansur, R. L., Westinghouse Electric and Manufacturing Company, Boston, Mass.
Miller, J. G. (Member), Zone Constructing Quartermaster Army Base, Boston, Mass.
Powers, H. B., General Electric Company, Schenectady, N. Y.
Rich, T. A., General Electric Company, Schenectady, N. Y.

2. Middle Eastern

Allison, A. J., General Electric Company, Philadelphia, Pa.
Beall, B. S., III, General Electric Company, Philadelphia, Pa.
Bibbs, J. C., Jr., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Bigelow, W. B. (Member), Rural Electrification Administration, Washington, D. C.
Black, C. H., General Electric Company, Philadelphia, Pa.
Grasser, L. G., Electric Storage Battery Company, Cleveland, Ohio.
Hoskinson, J. F., B. F. Goodrich Company, Akron, Ohio.
Jarcho, H. G., War Department, Aberdeen Proving Ground, Md.
Ladenheim, E. L., United States Navy, Naval Academy, Annapolis, Md.
Loftheim, K. J., Babcock and Wilcox Company, Barberton, Ohio.
Moir, G. R., Babcock and Wilcox Company, Barberton, Ohio.
Moosmann, H. E., General Electric Company, Erie, Pa.
Simons, S., Ordnance Department, United States Army, Aberdeen Proving Ground, Md.
Stephan, R. E., Dravo Corporation, Neville Island, Pittsburgh, Pa.
Wallace, J. M., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

3. New York City

Bode, H. W. (Member), Bell Telephone Laboratories, Incorporated, New York, N. Y.
Crosby, W. L., Consolidated Edison Company of New York, Incorporated, New York, N. Y.
Dite, W., Signal Corps Laboratory, Fort Monmouth, Red Bank, N. J.
Kimmel, J., United States Army Signal Corps, Army Base, Brooklyn, N. Y.
Kingsbury, J. W., American Telephone and Telegraph Company, New York, N. Y.
Kunz, C. (Member), M. W. Kellogg Company, New York, N. Y.
Leek, F. L., Federal Shipbuilding and Drydock Company, Kearny, N. J.
Lester, P. S., Long Island State Park Commission, Wantagh, L. I., N. Y.
Lincoln, E. S. (Fellow), consulting engineer, New York, N. Y. (re-election).
Merrell, E. J., Phelps Dodge Copper Products Corporation, Yonkers, N. Y.
Nilan, J. J., Jr., Westchester Lighting Company, Mt. Vernon, N. Y.
Nill, E. P., Consolidated Edison Company of New York, Incorporated, New York, N. Y.
Pastorinsky, H., War Department, New York Signal Corps, Procurement District, Brooklyn, N. Y.
Reiner, J. D., New York and Queens Electric Light and Power Company, Flushing, L. I., N. Y.
Romnes, H. I., American Telephone and Telegraph Company, New York, N. Y.
Sigman, G. H., New York and Queens Electric Light and Power Company, Flushing, N. Y.
Zwick, G., United States Navy Department, New York, N. Y.

4. Southern

Charles, M. C. (Member), Tennessee Valley Authority, Chattanooga, Tenn.
Fraser, J. W. (Fellow), J. W. Fraser and Company Charlotte, N. C. (re-election).
Smith, R. L., Florida Power and Light Company, Miami, Fla.
Stroud, W. D., Okonite Company, New Orleans, La.

5. Great Lakes

Bowen, G. W., Central Illinois Light Company, Peoria, Ill.
Bush, C. R. (Member), Central Illinois Light Company, Peoria, Ill.
Heiney, C. H., General Electric Company, Jackson, Mich.
Holz, G. W., Lindberg Engineering Company, Chicago, Ill.
Johnson, M. E., 819 North Marshall Street, Milwaukee, Wis.
Killin, A. M. (Member), Union Carbide Company, Sault Ste. Marie, Mich.
Mackie, F. D., Madison Gas and Electric Company, Madison, Wis.
Nottingham, F. O., Jr. (Member), Purdue University, West Lafayette, Ind.
Peasley, F. S., Stone and Webster Engineering Company, Chicago, Ill.
Schlotterback, E. M., Central Illinois Light Company, Peoria, Ill.
Teach, C. L., Central Illinois Light Company, Peoria, Ill.

7. South West

Anderson, J. B., Public Service Company of Oklahoma, Tulsa, Okla.
Arnold, E. P., Western Union Telegraph Company, Dallas, Texas.
Buell, C. L., Western Union Telegraph Company, Dallas, Texas.
Carpenter, H., Ebasco Services, Incorporated, Dallas, Texas.
Denison, H. M., Kansas Gas and Electric Company, Wichita, Kans.
Duncan, R. J., Western Union Telegraph Company, Dallas, Texas.
Grandfield, V. O., Kansas Gas and Electric Company, Wichita, Kans.
Johnson, F. K. L., Curtiss-Wright Corporation, Robertson, Missouri.
Kantenberger, W. J. (Member), 740 South Hampton Road, Dallas, Texas.
Matson, C. E., Kansas Gas and Electric Company, Wichita, Kansas.
McBrayer, C., Signal Office, 8th Corps Area, Fort Sam Houston, Texas
Moody, A. F., Western Union Telegraph Company, Dallas, Texas.
Moore, J. C., Western Union Telegraph Company, Dallas, Texas.
Scribner, G. R., Southwestern Bell Telephone Company, Kansas City, Mo.

8. Pacific

Baldwin, A. T., Southern California Edison Company Limited, Los Angeles, Calif.
Earl, W. S., Lockheed Aircraft Corporation, Burbank, Calif.
Grosch, J. G., 311th Signal Aviation Company, March Field, Calif.
Kelly, E. L. (Member), Bethlehem Steel Company San Francisco, Calif.
Kloski, L. A., Navy Yard, Mare Island, California.
Osteen, W. C., Southern California Edison Company, Limited, North Long Beach, Calif.
Rollins, C. A., Ferguson and Carollo, Phoenix, Arizona.
Seemann, R. E., United States Navy, Bethlehem Steel Company, Shipbuilding Office, San Francisco, Calif.
Speir, F. H., Pacific Gas and Electric Company, Emeryville, California.
Weck, W. C., Jr., Navy Yard, Mare Island, Calif.
Williams, I. A., Cutler-Hammer, Incorporated, San Francisco, Calif.
Wright, E. E., Navy Yard, Mare Island, California

9. North West

Duffy, M. D., Northwestern Electric Company, Portland, Oregon.
Gardiner, F. E., Mountain States Telephone and Telegraph Company, Butte, Montana.
Herman, C. J. (Member), Mountain States Telephone and Telegraph Company, Helena, Montana.
Hill, C. C. (Member), Mountain States Telephone and Telegraph Company, Helena, Montana.
Karns, I. H. (Member), United States Department of Interior, Billings, Montana.
Tellwright, F. D., Pacific Telephone and Telegraph Company, Portland, Oregon.

10. Canada

Cory, S. A., Small Electric Motors Limited, Leaside, Toronto.
Evans, T. O., Montreal Island Power Company, St. Vincent de Paul, Quebec.
Flannery, D. T. (Member), Hydro-Electric Power Commission of Ontario, Toronto (re-election).
Franks, N., Canadian General Electric Company, Limited, Toronto, Ont.
Hughes, T. J., Allied Brass, P. O. Box 300, Place d'armes, Montreal.
McQuarrie, A. M., Canadian General Electric Company Limited, Peterborough, Ontario.

Total, United States and Canada, 94

Elsewhere

Beard, J. R. (Fellow), Merz and McLellan, Milburn, Esher, Surrey, England.
Glasser, O. J., United States Army, Signal Company Aircraft Warning, Fort Buchanan, Puerto Rico.
Hall, R. D. (Member), Vogue Theatres, Kingswood, South Australia.
Hunter, C. D., United States Navy, Submarine Base, Coco Solo, C. Z.
Koh, N. P. (Member), Hong Kong University, Hong Kong, China.
Narayanlal, R., Government Workshop Technical Institute, Dehri, India.

Total, elsewhere, 6

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the addresses as they now appear on the Institute record. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Andriessen, Rienk, 54 Division St., Schenectady, N. Y.
Bedford, P. L., 625 W. Arlington St., Chicago, Ill.
Bluethental, Herbert, Jr., 902 Concord Ave., Wilmington, Del.
Brown, Charles A., 14631 Valerio St., Van Nuys, Calif.
Clinchard, W. C., Jr., Fajardo Sugar Co., Fajardo, P. R.
Cox, Irwin W., 924 E. Wells, Milwaukee, Wis.
Di Addario, Thomas, 3110 Wisteria Ave., Baltimore, Md.
Ernestus, A. W., 137 S. 15th St., Allentown, Pa.
Freed, John H., Olson Construction Co., 410 W. 7th St., Lincoln, Nebr.
Gregory, Herbert Scott, Y. M. C. A., Schenectady, N. Y.
Kaylin, Rubin Robert, 930 Lenox Road, Brooklyn, N. Y.
Keller, Ernest Lee, 1303 E. 8th St., Anderson, Ind.
Klatte, A. J., 5505 Agatite Ave., Chicago, Ill.
Kryder, Paul A., 1527 North 52nd, Milwaukee, Wis.
Lancaster, Eugene L., Jr., 646 N. Congress, Jackson, Miss.
Martinez, Joseph D., 550 Florence Ave., Downey, Calif.
Myers, W. H., 505 West Seaside, Long Beach, Calif.
Phillips, C. Vernon, 1019 Humboldt St., Manhattan, Kans.
Radcliffe, J. H., 334 Reid St., Peterboro, Ont., Can.

19 Addresses Wanted

Recent Section Meetings

Section	Date	Speaker	Topic and Activity	Attendance
Akron	3/11/41	K. F. Sibila, U. of Akron	"Surface Hardening by Induction"; dinner and motion pictures	68
Arizona	3/22/41	Mrs. E. W. Rockwell, Lockheed Aircraft Co.	"Application of Electricity in the Airplane Industry"; organization meeting; election of officers	41
Boston	3/11/41	M. E. Strieby, A.T.&T. Co.	"Wire Line Network for Television"; dinner	113
	3/ 8/41	Harlow Shapley, Harvard Astronomical Lab.	"Comets"	126
Cent. Indiana	3/18/41	J. E. Hobson, W.E.& M. Co.	"The Application of Capacitors," illustrated	45
Cincinnati	2/19/41	Lt. Col. L. A. Codd	"Rearmament Program"	490
	3/19/41	C. F. Wagner, W.E.&M. Co.	"Mechanical Analogy of Transmission Line Surges"; dinner	80
		Lieut. York, Cincinnati Police Dept.	"Safety on the Highway"	
Cleveland	3/ 4/41	H. B. Osborn, Jr., Ohio Crankshaft Co.	"Case Hardening by High-Frequency Induction"; technical group mtg.; inspection trip through plant	76
	3/20/41	H. C. Koenig, Elec. Testing Labs. Inc.	"Uncommon Tests of Common Devices"; dinner	131
	4/ 1/41	W. I. Senger, Gisholt Machine Co.	"Dynamic Balancing Machines"; technical session meeting	87
Denver	3/28/41	W. R. Young, U. S. Bur. Reclamation	"Aspects of the Central Valley Project"	42
East Tenn.	3/17/41	C. A. Powel, W.E.&M.Co.	"Electricity in National Welfare"; dinner	55
Erie	3/18/41	T. F. Perkinson, Gen. Elec. Co.	"Some Aspects of Railroad Electrification"	12
Florida	3/21–22/41		Annual convention of Florida Engg. Society	158
Georgia	3/10/41	J. O'D. Shepherd, Southern Bell Tel. Co.	Discussion following luncheon and films	45
	3/18/41	C. A. Powel, W.E.&M. Co.	Discussion of new devices and methods in defense work	35
Houston	3/13/41	J. L. Hamilton, vice-pres., South West Dist.	Executive committee dinner	15
	3/17/41	J. O. Perrine, A.T.&T. Co.	The Artificial Creation of Speech	1,600
Iowa	3/26/41	R. L. Witzke, W.E.&M. Co.	"A Visual Demonstration of Transient Phenomena"; joint meeting with U. of Iowa Branch	135
	4/ 2/41	Lt. Col. E. D. Cameron, Jr., 7th Corps Area	"Signal Communications in the Army"; joint with Iowa State Coll. Branch	125
Kansas City	3/ 5/41	J. O. Perrine, A.T.&T. Co.	"The Artificial Creation of Speech'; exec. com. dinner meeting	850
Los Angeles	3/11/41	N. B. Hinson, A. A. Kroneberg, H. A. Lott, Southern Calif. Edison Co. Ltd.	"Interconnections Between Elec. Utility Systems in Southern Calif."	165
		J. Marshal, student, U. So. Calif.	"Yellowstone National Park"	
		S. Gally, student, Calif. Inst. of Tech.	"History of Land Occupied by City of Pasadena and CIT"	
Louisville	3/21/41	J. R. Weaver, W.E.&M. Co.	"Industry in Defense"	24
Madison	3/ 7/41	V. K. Zworykin, RCA Laboratory	"Image Formation by Electrons"	300
	3/29/41	R. W. Sorensen, pres., AIEE	"Engineering Horizons, Limited"	49
Mansfield	3/14/41	C. J. Phillips, Corning Glass Works	"Modern Miracles in Glass"; illustrated	52
	3/20/41	C. F. Wagner, W.E.&M. Co.	"Mechanical Analogy of Transmission-Line Surges"	76
Maryland	3/ 3/41		Inspection trip to Boys' Vocational School	52
	3/17/41	F. M. Herring, Baltimore Transit Co.	"Electric Overhead Switches for Trackless Trolleys"	132
		O. E. Kirchner, American Airlines, Inc.	"Operation of Commercial Airlines"; dinner and motion pictures	
Memphis	3/18/41	C. L. Allday, Vocational School for Nat. Def.	"Work Being Done for Promotion of National Defense"	44
		C. W. Penry, same	"Value of Airplanes and Trained Personnel"	
Michigan	3/18/41	C. F. Wagner, W.E.&M. Co.	"Traveling Waves in Transmission Systems"; dinner	200
Milwaukee	3/29/41	R. W. Sorensen, pres., AIEE	"Engineering Horizons, Limited"	
	4/ 2/41	A. O. Hansen, U. of Wisconsin	"Atom Smasher"	85
Minnesota	3/ 3/41	A. G. Gutteridge, Melbourne, Australia	"Description of Industrial Development in Australia"	100
		W. A. Hanley, Eli Lilly Co.	"National Defense From an Engineer's Viewpoint"	
	3/27/41	R. W. Sorensen, pres., AIEE	"Engineering Horizons, Limited"	60
	4/ 1/41	A. C. Monteith, W.E.&M.Co.	"Trends in Electrical Apparatus Development"	47
Montana	3/24/41	R. W. Sorensen, pres., AIEE	"Engineering Horizons, Limited"	40
Muscle Shoals	2/14/41	W. E. Comb, Electro Metallurgical Co.	"Ferrosilicon"	30
	3/14/41	M. K. Bryan, Chas. T. Main, Inc.	"Watts Bar Steam Plant Design"	42
N. Mex.–W. Texas	3/ 6/41	R. B. Bonney, Mountain States Tel. & Tel. Co.	"Research Ramifications"; dinner	20
	4/ 1/41	J. L. Hamilton, vice-pres., South West Dist.	"Engineering—Past, Present, and Future"; dinner	22
New Orleans	2/28/41	F. M. Clark, G.E. Co.	"Limitations for the Successful Use of Commercial Dielectrics"	53
Niagara Frontier	3/21/41	E. H. Roy, Station WBEN	"Facsimile Transmission"; dinner meeting	52
Oklahoma City	3/11/41	J. O. Perrine, A.T.&T. Co.	"The Artificial Creation of Speech"	1,875
	3/31/41	R. W. Sorensen, pres., AIEE	Brief talk	131
		M. H. Cook, Western Elec. Co.	"Manufacture of the Combined Telephone Set"	
Philadelphia	3/11/41	W. C. Brown, G.E. Co.	"What's New in Lighting"	510
Pittsburgh	2/25/41	Lt. Com. J. P. Thew, General Motors Corp.	"The Submarine"; dinner; motion pictures; joint with elec. sec., ESWP	450
	3/11/41	J. B. Hodtum, Allis-Chalmers Mfg. Co.	"Power-Factor Testing of Transformer Insulation"; joint with elec. sec., ESWP	118
	3/25/41	E. D. Youmans, Okonite Co.	"Developments in Rubber Insulation"	136
Portland	2/27/41	P. Peterson, Control Corp.	"Demonstration and discussion of problems of remote control and telemetering; trans. and dis. com. group meeting	75
	3/17/41	R. W. Sorensen, pres., AIEE	"Engineering Horizons, Limited"	77
	3/25/41	L. L. Smith, Pacific Tel. & Tel. Co.	"The Transmission Phases of Exchange Plant Design"; communication com. group meeting	23
Providence	1/14/41	H. C. Drake, Sperry Products, Inc.	"Flash Butt Welding of Rails"; slides and motion pictures	25
	2/ 4/41	F. W. Bush, Allis-Chalmers Mfg. Co.	"Trends in the Design of Modern Power Transformers"	75
		R. W. Sorensen; H. H. Henline	Institute activities	
	3/11/41	Capt. C. H. J. Keppler, U.S.N.	"Types and Organization of U. S. Ships"; motion pictures	75
St. Louis	3/ 6/41	J. O. Perrine, A.T.&T. Co.	"The Artificial Creation of Speech"	2,813
San Antonio	2/25/41	C. E. Hicks, Lower Colorado River Authority	"Carrier Relaying on Lower Colo. High Line Transmission"	60
	3/14/41	J. L. Hamilton, vice-pres., South West Dist.	"Engineering—Past, Present, and Future"	50
	3/18/41	J. O. Perrine, A.T.&T. Co.	"The Artificial Creation of Speech"	57
San Diego	3/19/41	B. B. Gravitt, G.E. Co.	"Electrical Developments in 1940"; motion pictures	19
Schenectady	1/16/41	J. V. B. Duer, Penn. Railroad	"Electricity and Railroads" (technical discussion series)	100
	1/24/41	W. A. Hanley, president ASME	"Why National Defense?"	25
	2/13/41	H. H. Nugent, Rensselaer Poly. Inst.	"The Engineer as a Public Speaker"	115
	2/20/41	Messrs. Carnegie and Kelly, Gen. Motors Corp.	"Description of the Hydramatic Drive" (tech. discussion series)	360
Seattle	2/19/41	C. B. Ward	"Pathology Treatment by Use of X Rays"	90
		A. G. Friend	"History of the Electrocardiograph"	
		H. E. Nichols	"Development of the X-Ray Tube"	
	3/18/41	R. W. Sorensen, pres., AIEE	"Engineering Horizons, Limited"	85
Sharon	3/11/41	E. O. Altree, G.E. Co.	"Fluorescent Lamp Lighting"; motion pictures	190
South Bend	3/20/41	B. Waldman, U. of Notre Dame	"Applications of High Voltage to Nuclear Physics"; dinner	57
Spokane	3/14/41	J. D. Booth, W.E.&M. Co.	"Power Line Carrier Communication"	41
	3/21/41	R. W. Sorensen, pres., AIEE	"Engineering Horizons Limited"; dinner	40
Springfield	3/10/41	H. J. Holmquest, G.E. X-Ray Corp.	"Electrical Tools for the Medical Profession"	100
Syracuse	3/27/41	C. F. Wagner, W.E.&M. Co.	"Mechanical Demonstrator of Traveling Waves"; dinner	140
Toledo	3/26/41	E. G. Bailey, Babcock & Wilcox Co.	"Recent Progress in Steam Generation"; illustrated	400
Toronto	3/14/41	C. C. Rathgeb, Canadian Comstock Co.	"Important Electrical Installations Throughout the Dominion"	57
Tulsa	3/ 4/41	J. O. Perrine, American Tel. & Tel. Co.	"The Artificial Creation of Speech"	450

Recent Section Meetings (continued)

Section	Date	Speaker	Topic and Activity	Attendance
Urbana	2/26/41	Everett S. Lee, G.E. Co.	"Measurements in Industry"; joint with Univ. of Ill. Branch	100
	3/11/41	T. C. Shedd, U. of Ill.	"The Proposed Licensing Law for Engineers in Illinois"	12
Vancouver	3/19/41	R. W. Sorensen, pres., AIEE	"Engineering Horizons Limited"; dinner	47
Washington	2/11/41	M. G. Lloyd, National Bureau of Standards	"Electric Codes"	
		G. F. Daly, Int'l. Business Machines Corp.	"The Punched Card Method"	
		R. L. Palmer, Int'l. Business Machines Corp.	Demonstration of various machines	220
	2/27/41	Charles Kerr, Jr., Westinghouse E.&M.Co.	"Railroad Electrification"	78
	3/ 8/41	G. W. Spangler, Washington Terminal Co.	Conducted inspection trip	117
	3/17/41	P. Thomas, W.E.&M. Co.	"Adventures in Elasticity"	300
	3/27/41	R. G. Slauer, W.E.&M. Co.	"Illumination"	70
W. Virginia	2/14/41	J. R. Thumm, Owens-Corning Fiberglas Corp.	Discussion of electrical insulating properties of Fiberglas	26
Wichita	2/19/41	S. L. Goldsborough, Westinghouse E.&M. Co.	"Carrier Current Channels and Their Uses"; illustrated	34
	2/28/41	J. O. Perrine, American Tel. & Tel. Co.	"The Artificial Creation of Speech"	1,035
	3/24/41	J. L. Hamilton, vice-pres., South West Dist.	"Engineering—Past, Present, and Future"	33
Worcester	3/14/41	F. Mohler, G.E. Co.	"The Amplidyne—A New Tool of Many Uses"; dinner	80

Recent Branch Meetings

Branch	Date	Speaker	Topic and Activity	Attendance
Alabama Poly. Inst.	3/10/41		Business meeting	20
Alabama, Univ. of	3/17/41	D. D. Wendel, Alabama Power Co.	"Safety in the Field and Laboratory"	25
	3/31/41		Discussion of plans for coming Student Branch convention	38
Alberta, Univ. of	1/ 9/41	E. King, student	"Remote Metering"	24
		G. Sutherland, student	"Photography"	
	1/20/41	W. Baylis, student	"Radio Beam for Flying"	20
		D. Gardner, student	"Use of Wireless at Sea"	
	2/ 4/41	H. L. Creighton, student	"Clock Motors"	21
		S. C. Phillips, student	"First Aid to Electrical Shock"	
		M. Dewis, student	"The Canmore Mine"	
	2/26/41		Motion pictures	50
	3/12/41	D. Barchyn, student	"Lighting Systems"	21
		G. Hollenbach, student	"Selsyn Motors"	
	3/31/41	J. Martin, student	"Television Scanning"	18
		G. Osberg, student	"Airport Construction"; election of officers	
Arkansas, Univ. of	3/10/41	J. L. Hamilton, vice-pres., South West Dist.	"Engineering—Past, Present, and Future"	36
	3/12/41	F. L. Johnson, student	"Power Factor Correction"	16
		G. Scott, student	"Wave Dotter for Wave Oscilloscope"	
		H. Campbell, student	"Commutation as a Designing Problem"	
	3/19/41	Wm. Doyne, student	"Fiber Glass Insulation"; motion pictures	16
	3/26/41	F. Lewis, student	"High Efficiency Grid Modulation"	21
		J. Dragon, student	"Sodium Vapor Lamps"	
	4/ 2/41	E. A. Pittman, student	"Development and Increased Use of the Trolley Bus"	18
		H. Fristoe, student	Demonstration and talk on the theory of television transmission	
B. C., Univ. of	3/19/41	D. Bastin, student	"Photoelectric Pickup"	28
		E. Tuley, student	"Synchronous Ignition System"	
			Election of officers	
Brooklyn, Poly. Inst. (E.)	2/24/41	Capt. W. E. Appleton, U. S. Signal Corps	"Outline of Signal Corps of U. S. Army"	40
Calif., Univ. of	1/28/41	R. O. Brosemer, G.E. Co.	"General Electric Test Course"	52
	3/12/41	J. V. Lebacqz, Univ. of Calif.	"High Voltage Phenomena"; visit by Vice-Pres. H. W. Hitchcock	38
	3/14/41		Inspection trip to the Moore Drydock plant in Oakland	17
	3/27/41		Executive committee meeting	11
	4/ 2/41	D. I. Cone, Pacific Tel. & Tel. Co.	"Carrier Systems"	50
Clemson Agri. Col.	3/13/41	J. E. Woodward, student	"Cathode Vector Analysis"	26
		W. H. Wigington, student	"Train Automatic Signaling"	
	3/26/41	D. C. Sheldon	"Engineering Mathematics"	24
Colorado State Col.	3/24/41		Motion pictures	23
Colorado, Univ. of	2/ 5/41	L. M. Robertson, Public Service Co. of Colo.	"Power Systems"	30
	2/25/41	J. O. Perrine, A.T.&T. Co.	"The Artificial Creation of Speech"	1,200
Cooper Union	11/13/40	Mr. Krecreft, N. Y. Tel. Co.	"The Science Behind the Telephone"	54
	11/27/40	Wm. Pagdin, student	"Operation of Westinghouse Elevators"	28
	12/11/40	B. Loughlin, Hazeltine Service Corp.	"Phase Angle Measurements at High Frequencies"	27
	1/ 8/41	S. Bonwit, student	"Television Fundamentals"	42
	2/10/41	S. N. Baruch	"The Proposed 300,000-Volt D-C Transmission Line for the Bonneville and Coulee Dam Projects"	35
	2/28/41	S. Deutsch, student	"Repair of D-C Motors"	36
	3/20/41		Motion picture	26
	3/29/41		Inspection trip, propulsion power equipment of Ind. subway	19
Denver, Univ. of	3/ 6/41		Discussion of plans for future meetings	25
Idaho, Univ. of	3/11/41		Motion pictures and discussion of future plans	22
Ill. Inst. of Tech.	3/21/41	P. B. Juhnke, Commonwealth Edison Co.	"Operation of a Large Power System"	40
Iowa State Col.	4/ 2/41	Col. Cameron, Signal Corps, U. S. Army	Discussion of the part of the Signal Corps in army maneuvers	120
Iowa, Univ. of	3/12/41	D. J. Blacketer, student	"Use of Radio in Special Emergencies"	37
		B. Boyer, student	"Development of Television"	
		B. Blakesly, student	"How Fast Can We Fly"	
	3/26/41	R. L. Witzke, W.E.&M. Co.	"A Visual Demonstration of Transient Phenomena"	60
	4/ 2/41	E. L. Goss, student	"Ultrasonics"	34
		R. J. Fountain, student	"Niagara Falls Power"	
		H. R. Cummings, student	"Radio Advertising"	
Kansas State Col.	2/27/41	J. O. Perrine, A.T.&T. Co.	"The Artificial Creation of Human Speech"	1,200
	3/ 6/41	John Weary, student	"The Electrical System of the Automobile"	95
		John Newacheck, student	"The St. Lawrence River Project"	
	3/24/41	J. L. Hamilton, vice-pres., South West Dist.	"Engineering—Past, Present, and Future"	89
Kansas, Univ. of	3/ 6/41	L. L. Davis, Kansas City Pub. Serv. Co.	"Application of Electrical Energy to Transportation Problems in Kansas City"	40
Kentucky, Univ. of	3/21/41	G. Smithwich	"Ancient Customs and Modern Medicine in China"	60
	3/28/41	Paul Kintner, student	Talk	50

Recent Branch Meetings (continued)

Branch	Date	Speaker	Topic and Activity	Attendance
Lafayette Col.	3/ 5/41	P. R. Beard, student	"Electrical Control of A-C Frequency"	15
		F. T. Love, student	"Summer Work With the American Gas & Elec. Co."	
Louisiana State Univ.	3/11/41		Discussion of future plans	19
	3/18/41		Election of officers	30
Maine, Univ. of	3/13/41	R. E. Baker, Boston & Maine Railroad	"Air Brakes"	10
Manhattan Col.	3/19/41		Organization meeting	
Marquette Univ.	2/27/41	H. Rass, student	"Rectifiers"	10
		D. Thor, student	"The Calculating Board"	
	3/27/41	C. G. Miller, Weston Instrument Co.	"Electrical Indicating Instruments"	57
Maryland, Univ. of	3/12/41	H. Keller, student	"The Electrical Engineer in National Defense"	15
		R. Crump, student	"Power Rates"	
	4/ 2/41	G. L. Davies, Washington Inst. of Technology	"Instrument Landing of Airplanes"; election of officers	20
Michigan Col. of M.&T.	3/12/41	R. Cronshey, student	"Manufacture of Vacuum Tubes"	16
Michigan, Univ. of	3/20/41	J. S. Gault, Univ. of Michigan	"Induction Motors—Rotor Bar Currents"; illustrated	45
Mississippi State Col.	3/11/41	Z. G. Taylor and Mr. Smithley, G. E. Co.	Talk and demonstration on the development of the lamp industry	32
Mo. School of M.&M.	3/15/41	Sargeant Wickham, Mo. State Police	"State Police Radio System"	23
	2/12/41	L. L. Crump, James R. Kearney Corp.	Various difficulties encountered in design of elec. apparatus	27
Montana State Col.	3/25/41		Election of officers	30
	4/ 1/41	J. Cummings, student	"New Transformers"	27
		A. Dalcerro, student	"Santa Fe's New Freight"	
		T. Heberly, student	"Electric Timing Devices and Corrections"	
Nebraska, Univ. of	3/ 5/41	P. E. Massie, student	"Radio in Field Artillery"; motion pictures	43
	3/19/41	H. Bishop, student	"Neon Signs"	31
	4/ 2/41	L. Haining, student	"Radio for the Weather Man"	27
Nev., Univ. of	2/27/41	K. Knoph, W.E.&M. Co.	"Fluorescent Lighting"	11
Newark Col. of Engg.	3/10/41	R. A. Dehn, student	"An Electronic Frequency Meter"	40
		V. Friberg, student	"Vacuum Tube Characteristics With Cathode Ray Oscilloscope"	
		M. Bell, student	"Phase Measurement Based on Vacuum Tube Voltmeter Operation"	
	3/24/41	C. Oriel, student	"The Ionosphere"	29
		F. Slamer, student	"Saturated Iron-core Reactors"	
		S. Kauklis, student	"The Development of Fluorescent Lighting"	
New Mex. State Col.	3/13/41	A. Westbrook, student	"Impulse Testing"	12
	3/27/41	C. Fleissner, student	"A Review of Fluorescent Lamps and Lighting"	11
		H. Harris, student	"The Petersen Coil"	
New Mex., Univ. of	3/ 6/41		Inspection trip to local power plant	16
	3/19/41	J. L. Hamilton, vice-pres., South West Dist.	"Engineering—Past, Present, and Future"	23
	4/ 3/41		Motion pictures	16
N. Y., Col. of City of	3/13/41		Motion pictures	50
New York Univ.	3/ 7/41		Election of Harold Eskin as secretary	22
N. C. State Col.	3/ 4/41		Discussion of fair exhibits	41
N. Dak., Univ. of	3/13/41		Business meeting	14
	3/27/41		Business meeting	10
Northeastern Univ.	3/11/41	Wm. Lamb, student	"Manufactured Switchboards"	20
	3/18/41	L. Ellms, Ohio Brass Co.	"Manufacture of Electrical Porcelain"	53
Notre Dame, Univ. of	3/ 4/41	H. L. Olesen, Weston Elec. Instrument Co.	"Six Types of Mechanisms Used in Weston Instruments"	35
	3/25/41	Mr. Peasely, Bendix Corp.	"What Is Expected of an Engineer"	33
Ohio Northern Univ.	3/27/41		Quiz program	34
Oklahoma A.&M. Col.	3/ 3/41	J. O. Perrine, A.T.&T. Co.	"The Artificial Creation of Speech"	1,400
	3/22/41	J. L. Hamilton, vice-pres., South West Dist.	"Engineering—Past, Present, and Future"	31
Oklahoma, Univ. of	3/12/41	J. B. Milner, student	Topics of general engineering interest	15
		L. Dorsett	"Seismograph Work"	
Pratt Inst.	3/15/41		Inspection trip to Underwriters' Labs. Inc.	7
Rensselaer Poly. Inst.	12/11/40	G. L. Johnson, Bell Tel. Labs.	"Carrier Currents' Place in Telephony"; illustrated	38
	2/18/41	J. L. Harvey, New York Power & Light Corp.	"Problems Which Occur in Power Production"	43
	3/11/41	K. P. Applegate, Hartford Power & Light Co.	"Specifications for Engineering Success"	40
R. I. State Col.	10/30/40	W. B. Hall, counselor	"General Aspects of Frequency Modulation and Television"	25
	11/20/40	G. W. Patten, G.E. Co.	"Motor Control Relays"	25
	1/15/41	R. E. Secord, Narragansett Elec. Co.	"Problems and Methods of Power Distribution"	28
	2/25/41		Business meeting	18
	3/ 4/41	H. C. Rankin, New England Power Co.	"Metering a Billion Dollars Worth of Power"	28
	3/18/41	H. A. Baines, Narragansett Elec. Co.	"The Unexpected Wants You—Prepare"	35
S. Dak. State Col.	3/14/41		Election of officers	15
So. Calif., Univ. of	3/ 5/41	L. Wilson, student	"Power Factor Measurements by the Vacuum Tube Voltmeter"	26
		P. Belsky, student	"Flux Patterns by Commutator Investigations"	
		E. Romero, student	"Science and Engineering at the Univ. of Southern Calif."	
		R. Hedges, student	"Electrical Method for Automatic Musical Transcription"	
	3/18/41	Edwin Morris, Westinghouse E.&M. Co.	"Industrial Electronic Applications in Los Angeles"	26
Stanford Univ.	4/ 3/41	C. Kresser, W.E.&M. Co.	"Ignitron Rectifiers"	30
Syracuse Univ.	1/18/41	L. F. Polisse, student	"New York Central Railroad's Automatic Train Control"	14
	3/15/41	A. Wolfe, student	"Key West-Havana Cable"	12
	3/22/41	C. W. Perry, student	"Optimum Voltages for Airplanes"	12
		R. Reinnagel, student	"History of Engineering"	
	3/29/41	I. M. Laurien, student	"Cyclatron"	11
	4/ 5/41	D. F. Ames, student	"Electron Microscope"	12
Texas Tech. Col.	3/20/41	J. L. Hamilton, vice-pres., South West Dist.		19
Texas, Univ. of	3/14/41	J. L. Hamilton, vice-pres., South West Dist.	"What AIEE Offers to the Electrical Engineer"	30
	3/16/41	J. C. Perrine, American Tel. & Tel. Co.	"The Artificial Creation of Speech"	276
Tufts Col.	3/27/41	E. W. Davis, Simplex Wire & Cable Co.	"What the Engineer Should Know"	30
Virginia Poly. Inst.	3/20/41		Business meeting	30
	3/28/41	Mr. Rabb, student	"Trying to Kill Micro-Organisms by the Use of High-Frequency Electricity"	32
Washington State Col.	3/13/41		Election of officers	59
	3/21/41	R. W. Sorensen, pres., AIEE	"The AIEE and Engineering in General"	55
	3/27/41		Election of officers	60
Washington Univ.	3/24/41		Discussion of final plans for Engineers' Day	21
West Virginia Univ.	3/17/41	Mr. McCarty, student	"Mines and Countermines"	38
		Mr. Reeser, student	"The Audio Noise of Transformers"	
		Mr. Alli, student	"Automatic Control of Aircraft"	
		Mr. Deegan, student	"Magnetic Pull in Relays"	
	3/24/41	Mr. Ferguson, student	"Effect of Electric Current on Man"	38
		Mr. Linn, student	"Hydrogen Cooled Synchronous Converter"	
		Mr. Rogers, student	"High Altitude Speed Test of Interceptor Plane"	
		Mr. Kelman, student	"The Evolution of Frequency Modulation"	
Wyoming, Univ. of	4/ 1/41	S. Phillips, student	"Radio Ranges for Guiding Aircraft"	16

Of Current Interest

National Defense

Electric Power

The electric-power industry was termed a key industry in national defense by George A. Davis, vice-president, Oklahoma Gas and Electric Company, in an address at the 13th annual engineering conference of the Missouri Valley Electric Association, of which he is president. He said that the United States in its present defense effort is more dependent on adequate power supply than in perhaps any other period of its history, and for that reason the electric-power industry is vital in national defense.

"The industry is clearly conscious of its responsibility," he declared, "and is co-operating with the Federal Power Commission to determine where additional power will be needed. While there are some apparent disagreements over power needs in certain critical areas in 1942, there are two important differences between the present power-supply situation and that in 1917–18." These, as reported by *Electrical World* are:

1. In the present situation large additions to capacity are already under construction throughout the country, whereas in 1917–18 the industry postponed or curtailed construction because of rising costs.

2. Present advanced technical knowledge permits the power industry to take full advantage of interconnecting networks, a condition which was impossible in 1917–18.

ST. LAWRENCE SEAWAY PROJECT DEBATED

Proponents and opponents of the St. Lawrence River Seaway–Power Project are debating the advisability of undertaking the project at the present time. Approval of the project as a national-defense measure has been asked by President Roosevelt on the basis of an agreement coming under the Canadian American Treaty of 1909 and therefore requiring only a simple majority vote in each house of Congress.

Opponents of the project point out that should a power need develop during the national emergency in the area that could benefit from the St. Lawrence project, such need would have to be met by other means because power could not be developed in the proposed St. Lawrence plant before 1945. Therefore undertaking the project now would impose an added burden on the construction industry without contributing anything substantial to the present emergency. They point out also that no general shortage of electric power has been shown, and that furthermore modern steam plants can produce and deliver energy more economically than hydroelectric plants which must deliver their product over long distances. Also it is said that the waterway would be particularly vulnerable to enemy attack, and that therefore the construction of ocean-going ships in the Great Lakes would not be feasible.

Proponents of the project point to the advantages of low-cost water transportation from the Great Lakes region to the Atlantic, and draw a parallel between the present situation and the situation existing when the Erie Canal was built. They also emphasize the advantages of establishing a great shipbuilding industry in the landlocked and protected waters of the Great Lakes.

A lively debate is expected in both houses of Congress.

FEDERAL POWER COMMISSION CITES GAINS IN ANNUAL REPORT

"Adequate and dependable power supply to meet the requirements of expanding defense orders can only be assured through careful planning, because it takes from 18 months to 2 years to construct a steam-generating station, and frequently longer to build a hydroelectric project," says the 20th annual report of the Federal Power Commission recently issued. Such planning has been undertaken, the report adds, at the direction of the President and in co-operation with the Advisory Commission to the Council of National Defense, the National Power Policy Committee, and the publicly and privately owned utilities concerned.

Foundation of the defense power program, the report states, is the National Power Survey made by the Commission in 1935 which was continued by direction of the President in March 1938.

Since June 14, 1940 the Commission has been engaged in carrying out the instructions of the President in his letter of that date, in which he called upon the Commission (*a*) to translate national-defense orders into demands for power; (*b*) to keep check on the adequacy of the power supply to meet such demands; (*c*) to keep currently informed of the needs of the national-defense industries; (*d*) to keep records of the orders being placed with the electrical-equipment industry for additional capacity and the ability to meet such orders; (*e*) to plan, in co-operation with the utility industry, to meet every power need in the most economical manner; and (*f*) to work out plans, in co-operation with the utilities and other government agencies, for the protection of power supply against hostile acts.

Concrete examples of the results already obtained from defense work are stated in the report to be:

1. Increased generating capacity under construction due in part to Commission efforts, evidenced by comparison of the 5,500,000 kw under construction in 1940 with the 1,600,000 kw under construction in 1938; and an accelerated construction schedule that will put into operation in 1941 a considerable amount of new capacity originally planned for installation later. Most notable example of this activity is the action initiated by the Commission to increase capacity in the TVA area.

2. Standardization of the sizes, steam pressures, and voltages of steam turbine generators among the different manufacturers, which was worked out in a series of conferences with representatives of the electric utilities and the equipment companies.

3. Preparation of confidential instructions for restricted distribution to operating officials for the protection of generating plants against sabotage or other hostile acts.

4. Major assistance in the development of mobile generating stations and mobile transformer units, now being manufactured in commercial quantities, which have already proved their worth in emergency cases.

5. Investigating and reporting, in co-operation with other agencies, on the needs of electrical equipment and the requirements for priorities where such needs exceed the supply.

6. Definition of areas in the country where the power supply is adequate to meet the expanding needs of industry, to assist in the location of national-defense industries in such areas.

7. Investigation, in co-operation with the utilities, of the feasibility of a giant network of high-capacity transmission interconnections tying together the major power-market centers of the Eastern industrial areas.

8. Assistance to the Army and Navy in securing reliable power for their rapidly expanding needs at army camps, air bases, navy yards, and torpedo stations at reasonable rates.

POWER PRODUCTION BEGUN AT GRAND COULEE

Power production from two 10,000-kw generating units began March 22, 1941, from the powerhouse of the Grand Coulee project, two years ahead of schedule. These generators, which are station-service units, are pygmies compared with the 108,000-kw units, the first of which is expected to be completed in August of this year; another is expected to be completed in November, and a third early in 1942.

NEW GENERATOR AT WHEELER DAM

A fourth 32,400-kw generating unit was placed in operation at Wheeler Dam March 13, bringing the total installed capacity at this plant to 129,600 kw. The initial installation at this plant when completed in 1936 consisted of two units; a third was placed in operation in January 1941. Space has been provided for an ultimate installation of eight units.

Industrial Plant Expansion

Industrial-plant construction for defense purposes now includes 784 plants costing $2,138,000,000, according to a recent issue of *Engineering News Record*. This is regarded as a conservative figure because it includes only those the financing of which the United States or British government have had a hand, or for which permission for five-year tax amortization has been obtained.

The Office of Production Management has announced the appointment of a plant-site committee headed by Director Nelson of the division of purchases. Projects for new plants and initial suggestions for site locations are made by the Army and Navy, the legally authorized contracting agencies. In reviewing and approving additional plants and facilities the commiteee will give

special consideration to needs for expediting defense production, associated military factors, geographic decentralization of defense industries, and employment of available labor.

SOME CURRENT EXPANSION PROGRAMS

Some recently reported plant-expansion programs related either directly or indirectly to the national-defense program are as follows:

Westinghouse Electric and Manufacturing Company. A new three-story office building and expanded manufacturing facilities feature the expansion program of the Westinghouse Electric and Manufacturing Company's South Philadelphia works. The new building houses the company's 600 office and engineering personnel and is completely modern. Its features include continuous-strip fluorescent lighting throughout; air conditioning; soundproof floors and ceilings; and glass-block windows with double-pane "islands" of clear glass. The air-conditioning system includes steam-jet refrigeration and electrostatic air cleaning. In summer, the cooling load will be lessened by a two-inch deep "lake" of water on the roof which will absorb part of the heat of the summer sun and dissipate it by evaporation. The lighting system includes some 3,600 continuous-strip fluorescent fixtures, totaling more than three miles in length and consuming approximately 200 kw. Highest illumination in the structure is in the 300-foot-long engineering drafting room where an average level of 50 foot-candles is obtained; the level in general offices is from 30 to 35 foot-candles.

Steam turbines having an aggregate capacity exceeding 7,000,000 horsepower are being produced in the current program for naval vessels at this Westinghouse plant. Power-plant and industrial turbines with a total capacity of 2,400,000 horsepower also are being produced. To carry out this program, the plant is working 24 hours a day and the company is spending some $9,000,000 for new manufacturing shops, machine tools, and reorganization of manufacturing facilities. The plant extension program, begun last fall, is expected to be completed in 1941.

General Electric Company. At the Erie, Pa., plant of this company, new facilities are being set up in two buildings, one for the manufacture of turbines and one for gun mounts. Machine work on some of the lathes and boring mills needed for this program is being done partly in the General Electric plant under assignment of the Niles, Ohio, Tool Company, which is building the machines.

North American Aviation Corporation. At the Dallas, Texas, plant of this company a new $7,000,000 plane-assembly plant has been built and equipped to turn out more than 250 bombers monthly. Adoption of new construction routine enabled this plant to be completed in 130 days. The construction method used in erecting this building, which employed prefabricated cellular-steel bomb-resisting insulated structural units, has proved so satisfactory that it is being used in a second plant now being constructed at Kansas City, Kans.

Owens-Corning Fiberglas Corporation. This company has purchased the Lonsdale Company mill in Ashton, R. I., to expand the production of Fiberglas. This plant is to be adapted for the manufacture of fibrous glass that subsequently is woven into all-glass tapes and cloths. These are used for a variety of purposes, many of them urgently needed for defense.

Sprague Specialties Company. New machinery has been installed for the production of defense products in the company's second factory, acquired several years ago in North Adams, Mass.

B. F. Goodrich Company. A $300,000 manufacturing plant has been completed at Akron, Ohio, by this company for the expansion of facilities for processing products from Koroseal. The new plant will augment present production facilities for the treating of fabrics and manufacture of cements and lacquers, and will initiate production of a special film for packaging materials and for general industrial use. A substantial part of current production is said to be for national-defense needs.

National Roster of Scientific and Specialized Personnel

In about four months, America's Roster of Scientific and Specialized Personnel (*EE, Dec. '40, p. 521*) has listed and classified a total of 150,000 persons, and it is hoped that eventually a half million will be included in this index of the nation's scientific and technical skill, according to a report in the March 29, 1941, issue of *Science News Letter.*

Questionnaires have gone to persons engaged in practically all branches of technology and engineering, including the AIEE membership. Response to the questionnaires is said to have been excellent. Among the physicists, the first scientific field to be canvassed, 75 to 80 per cent of the questionnaires were put on file after a single mailing and one postal card reminder to those whose response was somewhat delayed. The classification of the personnel answering the questionnaire is accomplished by special machines by means of which punched cards are prepared, the holes punched in the cards indicating the various skills possessed by the individual. Sorting machines facilitate finding the personnel having any given training or skills.

The roster is proving particularly valuable in meeting the needs of the defense program for personnel having scientific and technical abilities.

National Defense a Leading Convention Topic

Technical and engineering societies are making the national-defense program a principal topic of discussion at current meetings and conventions. Three of the most recent conventions featuring this topic were those held by the American Society of Tool Engineers, Detroit, Mich., March 25–29; American Society of Mechanical Engineers, Philadelphia, Pa., April 22–23; and Chamber of Commerce of the United States, Washington, D. C., April 28–May 1.

Tooling up for defense formed the keynote of the Tool Engineers' convention and "education for defense" the central theme of the accompanying Machine and Tool Progress Exhibition. Attendance records were said to be broken by both the convention and the exhibition. The ASME meeting consisted primarily of a management conference on national defense and featured discussions on subcontracting problems, selection and training of industrial personnel, labor problems, and quality control. At the Chamber of Commerce meeting, the emphasis was on national-defense issues, with discussions relating to natural resources, labor relations, foreign trade, trans-

In the large drafting room of the new office building at the Westinghouse Electric and Manufacturing Company's South Philadelphia Works, some 300 engineers and draftsmen work under special fluorescent lighting. The average illumination level is 50 foot-candles

portation, consumer goods, supplies and prices, agriculture, insurance, Federal fiscal policies, and government regulation.

Positions to Be Filled Through Civil Service Examination

Notice of the following positions, which will be filled through civil service examinations, is published here as a service to members of the Institute. Application forms and full information as to requirements for examinations may be obtained from the secretary of the Board of United States Civil Service Examiners at any first- or second-class post office, or from the United States Civil Service Commission, Washington, D. C.

Engineers. On April 7, the United States Civil Service Commission announced a new examination for engineering positions in the Federal Government. Engineers making application for jobs, except those applying in chemistry, metallurgy, marine or naval architecture, should now apply under the modified terms of the new announcement. However, persons who have been rated eligible under the examinations announced in 1940 for mechanical, aeronautical, civil, or general engineer need not file new applications. They will be placed on the list of persons eligible for appointment as the result of the new examination. The positions pay from $2,600 to $5,600 a year. Applications will be rated as they are received at the Commission's Washington Office until June 30, 1942. Engineers qualified in the following specialized fields are particularly needed for the National Defense Program and are urged to file their applications at once: Aeronautical, agricultural (farm machinery), construction (airports and buildings), heating and ventilating, mechanical (industrial production and diesel design), ordnance, radio, safety, sanitary (especially public health), structural (building design), and welding. The duties of these positions will include design, construction, and research in the various branches of engineering. To qualify for the examination, applicants must have completed a four-year college course in engineering and have had broad and progressive engineering experience. In general, this experience should have been of a kind which required thorough knowledge of mathematics, economics, and the physical sciences. Under certain conditions additional engineering experience may be substituted for all or part of the education, and approved graduate study may be used for the experience requirement. The maximum age limit is 60 years.

Industry

Early Action Expected on Commercial Television

Approval of the modified standards presented by the National Television System Committee and announcement of the time for authorizing commercial television are expected as a result of hearings before the Federal Communications Commission March 20, 21, and 24, 1941.

The television standards as reported by W. R. G. Baker (A'19), chairman of the Committee, at the hearing contained some modifications made since they were reported to the FCC on January 27 (*EE, March '41, p. 145–7*). The number of scanning lines in the picture has been increased from 441 to 525, and the standard on synchronization broadened to allow the use of several alternative and interchangeable types of wave forms and modulation methods, until further tests determine the best method. The currently favored value of lines for color transmission was also modified, being increased from 343 to 375. Generally approved by witnesses at the hearings, the modified standards are expected to be accepted by the FCC as the official basis of the art of television.

Unless the national emergency prevents, the date at which commercial licenses will be issued is expected to be set for some time before the end of the year. General agreement was reached on proposed rules and regulations, except in the matter of the minimum number of program hours per week to be required in commercial broadcasting, for which the Commission suggested 30 hours and the commercial organizations favored from 10 to 15.

Wire and Cable Manufacturers Ask Return of Containers

Failure of industries to return empty shipping reels, spools, and cases in which wire and cable are delivered has resulted in an acute shortage of such containers which is threatening to delay delivery of national-defense orders, according to wire and cable manufacturers. New containers are not available in sufficient quantity for the need. Manufacturers are urging immediate return of all containers in order that present shipments may be expedited and time, labor, and materials required to build new containers may be conserved for defense purposes.

Power Facilities in Industry Reported by Census Bureau

A survey of power facilities in American industry, recently made public by the United States Bureau of the Census, shows a continued trend toward further electrification, with an increase in installed electric motors of 10,814,584 horsepower, or 30.8 per cent since the last similar survey made in 1929. Total horsepower used in American industry is 51,154,523.

The Census survey shows that 181,000 out of 183,277 factories now use power, in comparison with 193,969 out of 210,959 in 1929.

American factories are divided into those that have prime movers, and those that purchase power. The power-generating equipment in the first class amounted to 21,266,557 horsepower, and the plants driven by purchased energy had motor capacity for making use of 29,887,966 horsepower. Plants which produced their own energy showed a gain in power of 5.5 per cent in ten years while installed motors in those plants which buy energy increased 31.2 per cent.

The greatest gain in prime-mover installation was reported for steam turbines which increased by 3,564,826 horsepower, or 46.1 per cent. Steam-engine installation in these establishments decreased by 3,066,675 horsepower, or 31.9 per cent. Internal combustion engines increased by 568,958 horsepower or 46.1 per cent, and hydro-turbines and water wheels showed an increase of only 2.9 per cent. Factories having their own power plants reported as ordinarily idle 1,996,753 horsepower, indicating 19,269,804 horsepower actively in use, 65.6 per cent of which is used to drive electric generators. The kilowatt rating of electric generators in these establishments totaled 9,674,934, as against 7,793,875 kilowatts in 1929. Seventy per cent of these generators, as measured in kilowatt ratings, were driven by steam turbines.

The factories which purchased energy used a total of 45,040,866,703 kilowatt hours during the year, compared with 37,393, 833,046 ten years ago.

RCA to Build Radio Research Laboratories

One of the largest radio research laboratories ever constructed will be built by the Radio Corporation of America at Princeton, N. J., David Sarnoff (M'23), president of RCA announced recently. The building, which will be called "RCA Laboratories", will be headquarters for all research and original development work of RCA and for its patent and licensing activities.

The purpose of the new laboratories, according to announcement, is to promote the growth of radio as an art and industry, to meet the needs of national defense, and to develop new products which may supply post-war employment.

Otto S. Schairer (M'13) now vice-president in charge of RCA's patent department, will be vice-president in charge of RCA Laboratories, which are to include the patent department. Ralph R. Beal, research director, will have charge of research and original development, and Doctor C. B. Jolliffe (M'34) is to be chief engineer.

George Westinghouse Scholarships Increased. The scholarship value of the fourth annual George Westinghouse "work-learn" scholarship has been increased by $420, the Westinghouse Electric and Manufacturing Company and the Carnegie Institute of Technology announced recently. The ten five-year scholarships, which will be awarded to high-school students on the basis of competitive examinations, personality, and character, will total $3,420 this year. The participants will obtain practical experience in Westinghouse plants during five summer vacations and two college semesters, and will complete eight semesters of college class work at Carnegie. This co-operative educational program was instituted in 1938. When in complete operation, it will include 50 functioning scholarships, with 10 scholarships expiring and being given to new men each summer.

NBC San Francisco Building Under Way. Actual construction was begun during April on the National Broadcasting Company's projected "million-dollar building" to house stations KGO and KPO in San Francisco, Calif. O. B. Hanson, vice-president and chief engineer of NBC, arrived in San Francisco April 4 to give final official sanction to plans for the building. Ground was broken November 14, 1940, and the construction is expected to occupy about ten months.

"America's Factories". "America's Factories", the 55th in a series of pamphlets published by the Public Affairs Committee under the editorship of Maxwell S. Stewart, presents a survey of factory growth during the last four decades, which shows an increase in manufacturing output of 276 per cent from 1899 to 1937. According to the pamphlet, the possibilities for expanding America's manufacturing industries for defense are very favorable, since the automobile industry which is particularly adaptable for defense requirements, and the machinery and chemical industries, also vital for defense, showed the most striking gains. Copies may be obtained at 10 cents each from the Public Affairs Committee, 30 Rockefeller Plaza, New York, N. Y.

Machine Tool Electrification. The annual machine tool electrification forum sponsored by Westinghouse Electric and Manufacturing Company was held April 14–16, 1941, at East Pittsburgh, Pa. Production and design problems created by the national defense emergency in the machine tool industry were the principal topics of discussion. An open forum was held on the last afternoon of the meetings, for discussion of subjects preselected by machine-tool delegates.

Other Societies

1941 American Standards. Announcement of publication of the list of American Standards for 1941 was made recently by the American Standards Association. More than 400 standards are listed, including definitions, technical terms, specifications for metals and other materials, methods of test for the finished product, dimensions, safety provisions for machinery, and work methods. These cover every important engineering field, and serve as a basis for many municipal, state, and Federal regulations. The 1941 list may be obtained free of charge from the ASA, 29 West 39th St., New York City.

Future Meetings of Other Societies

American Institute of Chemical Engineers. Semiannual meeting, May 19–21, 1941, Chicago, Ill.

American Physical Society. 242d meeting, June 20–21, Providence, R. I.

243d meeting (Pacific Coast), June 1941, Pasadena, Calif.

American Society for Testing Materials. 44th annual meeting, June 23–27, 1941, Chicago, Ill.

American Society of Civil Engineers. Annual convention, July 23–25, 1941, San Diego, Calif.

American Society of Heating and Ventilating Engineers. Semiannual meeting, June 16–19, 1941, San Francisco, Calif.

American Society of Mechanical Engineers. Semiannual meeting, June 16–20, 1941, Kansas City, Mo.

Edison Electric Institute. June 2–5, 1941, Buffalo, N. Y.

Institute of Radio Engineers. Summer convention, June 23–25, 1941, Detroit, Mich.

National Fire Protection Association. Annual meeting, May 12–17, 1941, Toronto, Ontario, Canada.

Society for the Promotion of Engineering Education. 49th annual meeting, June 23–27, 1941, Ann Arbor, Mich.

Society of Automotive Engineers. Summer meeting, June 1–6, 1941, White Sulphur Springs, W. Va.

Joint Activities

Engineering Foundation Director O. E. Hovey Dies April 15

Doctor Otis Ellis Hovey, director of the Engineering Foundation since 1937, died April 15, 1941. He was born April 9, 1864 in East Hardwick, Vt., and received the degrees of bachelor of science, Dartmouth College, 1885; civil engineer, Thayer School of Civil Engineering, Dartmouth College, 1889; doctor of engineering, Dartmouth, 1927; and doctor of science, Clarkson College, 1933. After a year as instructor in engineering at Washington University, St. Louis, Mo., he became associated with the late George S. Morison, consulting bridge engineer of Chicago, with whom he worked from 1890 to 1896. In 1896 he became plant engineer of the Union Bridge Company at Athens, Pa., and in 1898 was sent to London by that company as consulting engineer on projects for building South African bridges. When the Union plant was bought by the American Bridge Company in 1900 he was made engineer of design for the latter at Pencoyd, Pa. He was transferred to New York in 1904 and became assistant chief engineer in 1907 and consulting engineer in 1931. In 1934 he went to Turkey to survey trade conditions for the company, and later in that year left the company and went into private practice. He was in charge of the engineering of a number of important projects, including emergency dams at the Panama Canal, extensive repairs on the Williamsburg Bridge, and building of the Port of New York Authority Bayonne Bridge. Dr. Hovey was the author of two books, "Movable Bridges", 1926–27, and "Steel Dams", 1935, and of various technical papers. He had been treasurer of the American Society of Civil Engineers since 1921 and an honorary member since 1937, and was also a member of The American Society of Mechanical Engineers, the American Society for Testing Materials, the American Railway Engineering Association, the American Welding Society, and the American Institute of Consulting Engineers.

Letters to the Editor

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Total Security—A Challenge

To the Editor:

Recently three articles in the technical press have come to my attention. One was by President Beard of the British Institution of Electrical Engineers, and appeared in the January 1941 issue of the I.E.E. *Journal*. Another was by W. L. Batt, past president of The American Society of Mechanical Engineers and appeared in the January 1941 issue of *Mechanical Engineering*. The third was by Charles E. Wilson, president of the General Electric Company, and was published in the March 1941 issue of ELECTRICAL ENGINEERING.

As an engineer, accustomed to reading these publications for technical information, I was interested and immensely impressed to note the emphasis which all these articles placed upon the morality of human relationships as a solution for present-day problems. It is also pointed out that leadership at this critical period must be in the hands of industrial executives and engineers rather than politicians.

The following are a few phrases quoted from these papers which I felt to be particularly significant. Mr. Beard says in his inaugural address: "Western civilization is nevertheless definable. It is the synthesis of three things: the Christian ethics, the scientific spirit, and the rule of law." At another point he says, "We as engineers must of necessity be called upon to play a major part in rebuilding the world, and we must place and equip ourselves for this task now."

The title alone of Mr. Batt's paper is significant: "Through A Glass, Darkly."

The title of Mr. Wilson's paper also is inspiring: "Total Security—a Challenge." In his discussion of "Moral Security is First Defense," Mr. Wilson refers to "the bonds of national unity which serve as a firm foundation for our moral security, the first fortification of our political and economic freedom." Later, in a summation of active steps to be undertaken, appears this remarkable statement:

> "With these thoughts in mind, then, the following steps represent the needs in this most critical stage—
>
> "1. Here I submit in all seriousness, as a first step: prayer, and a wholehearted practice of the Golden Rule."

The engineering professions have undoubtedly made great contributions to civilization as we know it today. However, everyone is beginning to realize that something besides technology is required to solve the problems which now face us all. It is inspiring to me that men of the caliber of those quoted all agree that the basic solutions to these problems are to be found, not in scientific publications, but in the Bible.

In so doing these men have presented a challenge to every other leader in the nation, whether he be in industry, in government, in labor, or elsewhere. It will be interesting to see who responds.

And it occurs to me that this challenge is not to leaders alone, it is to all of us—including you and me.

HARVEY P. SLEEPER (A'22, M'30)

(Operating engineer, Public Service Electric and Gas Company, Newark, N. J.)

To the Editor:

About six years ago, after the passage of the National Recovery Act, I, as president of the New York Association of Consulting Engineers, discussed with the secretaries of the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, and the American Society of Civil Engineers, the possibility of persuading the PWA to make use of the existing setup in the construction industry, and also the possibility of an NRA Code for engineers. As a result of those discussions, I became the correspondent, as a member of the Code committee, for a group of some 15 local engineering societies over the United States, who exchanged views among themselves and with the Code committee in a very constructive way. Inspired by the article "Total Security—a Challenge" in the March issue of ELECTRICAL ENGINEERING, I sent the following letter to the 25 consulting engineers who formed that circle of correspondents and to the secretaries of the national engineering societies.

"Dear Sir:

"Probably you have read two articles recently published in the engineering press, but if not, may I urge you not only to do so, but to study them carefully, for in my humble judgment they represent some of the most constructive thinking that has been done in this country in a long time.

"The first appeared in the January issue of *Mechanical Engineering* and was written by W. L. Batt, president of S. K. F. Industries, past president of American Society of Mechanical Engineers, and now on Office of Production Management staff in Washington. The article, entitled 'Through A Glass Darkly', pointed out the necessity of planning now in the midst of the emergency to avoid a nosedive and crack-up when it is over.

"The second article, entitled 'Total Security—A Challenge', in the March issue of ELECTRICAL ENGINEERING by Charles E. Wilson, president of the General Electric Company, proposed a definite program, requiring first an arm-in-arm accord among business, industry, labor, and government, from which certain courses of action would flow:

"First, a recovery stage.

"Second, a stabilizing program.

"Next, a backlog-building period to prepare for the slump after the war, and

"Last, the after-the-war period when with proper preparation we can pull out of the nosedive we certainly face.

"Mr. Wilson points out that the first move toward the arm-in-arm accord must come from business and industrial leaders and that the time at our disposal is short.

"The reason given for the preparation of these articles is the obvious fact that even though Britain wins, a new world will be born out of the tragedy which has overwhelmed Europe, and we will have to do business in that world, and unless we prepare realistically for that time we may be plunged into a depression far worse than the last one.

"Beyond that, and much more important in the long run, is the need so to prepare ourselves that we can help Britain persuade Europe to adopt democratic forms of government, by getting rid of dissension here and making democracy work better than any other scheme they may try.

"As Wilson points out, we are in the midst of a worldwide revolution in thought and ideas, which has been going on for 20 years and may continue for another 50 years, during which time the free-enterprise system has been and will continue to be severely tested.

"We can well believe that it is going to take a lot of faith and moral courage on the part of those leaders who undertake to break the ice to secure the arm-in-arm accord Wilson advocates. Therefore, it seems to me that we as engineers should recognize the responsibility of doing our share to help along such a move, and also to do some original thinking on our own account, as well as to take out our faith and moral courage and polish them up a bit ready for action.

"Mr. Wilson's address was given by him before the 1941 winter convention of the AIEE. It has been reprinted by the General Electric Company, which will send you a copy upon request."

JOHN G. EADIE

(Eadie, Freund, and Campbell, Consulting engineers, New York, N. Y.)

To the Editor:

As you and Mr. Wilson invited comments on his most comprehensive presentation of our national problem ("Total Security—a Challenge" by Charles E. Wilson, *EE, March, '41, p. 99–105*), permit me to observe that as citizens and officials we are very much like the leading character in Russell Conwell's "Acres of Diamonds". We have for over 150 years had a priceless gem or collection of gems and have proceeded to search Europe and Asia for panaceas entirely oblivious of our rich inheritance.

No less an authority than the Honorable William E. Gladstone termed our constitution "the most wonderful work ever struck off at a given time by the brain and purpose of man."

Its crowning jewel is the preamble which clearly states our national objectives.

Officially ratified, every loyal citizen should be dominated by its principles, for we are all committed to do our utmost to—"perfect national unity, establish justice, insure domestic tranquillity, provide for the common defense, promote the general welfare," and so on.

When, for instance, employers and employees, bankers and brokers, lawyers and clients, farmers and middlemen, and other groups seek to establish justice in their dealings with each other and with the public, then, and not till then, can they consider themselves worthy citizens of the republic whose flag they salute.

Just as Ohm's law dominates our electrical activities, so for total security the Preamble must dominate our personal and national activities, that our "government of the people, by the people shall not perish from the earth."

WM. B. TAYLOR (A'05, M'16)

(Electrical engineer, Plympton, Mass.)

To the Editor:

The article by Charles E. Wilson, in the March issue of ELECTRICAL ENGINEERING is worthy of much thought. It is also cheering because it illustrates a growing tendency to devote thought to problems of public welfare, on the part of intelligent men who have been traditionally too busy with their own affairs to "bother with politics". And such thought will show us, as Mr. Wilson implies, that the only hope of a solution for our problems lies in perceiving and expressing more of the Divine wisdom, which includes justice and love. "This also is a continuing necessity."

Mr. Wilson's thesis that there is a mass movement throughout the world toward revolution seems to be correct, but why? Why does the average man feel that he is being robbed of something which belongs to him? In this land of plenty, why is the annual income of 40 per cent of the families less than $1,000 per year? Is there a fundamental fault in our system which may account for much of our woe?

Let us see. All economists agree that three factories are necessary in production—labor, capital, and land, or natural resources.

The laborer is anyone who contributes by his own effort, mental or physical, to the general welfare. He supplies labor. Without him labor would not exist.

The capitalist is anyone who owns tools, machinery, or buildings used in production. He supplies the capital. Without him capital would not exist.

The landlord is anyone who holds title to natural resources. He supplies the natural resources with which both labor and capital must operate—or does he? Without him the natural resources would not exist—or would they?

On the contrary, the landlord, *as such*, performs no useful function at all commensurate with the large share of the product that he collects. And what he collects leaves that much less to be divided between labor and capital.

Is it conceivable that a wise and beneficent Creator designed the world as a means by which a few of his children should take away from the others a part of what those others produce, without rendering any return in goods or services? Is it not easier to believe that He designed the world for the use and benefit of mankind?

But "mankind" cannot operate my farm, nor your mine. How can this conflict be reconciled? Consider an example. My neighbor bequeathed his farm to his four sons jointly. Three of the boys had established other businesses and did not wish to change, but James wanted to run the farm. "Well," said James, "I will pay rent for the farm, and at the end of the year we will each take a quarter of the rent fund". This was satisfactory.

Applying this idea to the larger problem, we may let the community, as the repre-

sentative of "mankind", collect rent from me for the natural resources which I hold, and from you for those which you hold, leaving us both free to develop and use those resources. If this were done the community would have an income that would make taxes, as we know them at present, largely unnecessary. Furthermore, it would make possible a system of really free enterprise, free from much of the crushing burden of taxation and free from the necessity of paying tribute to the landlord before it could begin production. Henry George developed this philosophy quite fully years ago, and his reasoning has never been refuted.

May it not be that we are now being forced toward a choice between such a system of really free enterprise and some sort of totalitarian system?

This mass movement toward revolution may be a good thing or a bad thing. Hatred and short-sightedness may drive it toward anarchy and chaos. But wisdom and justice—enlightened self-interest, if you will—can lead it toward a higher civilization and a better humanity than the world has ever known.

J. B. Gibbs (M'35)

(Transformer engineering department, Westinghouse Electric and Manufacturing Company, Sharon, Pa.)

Some Characteristics and Applications of Negative-Glow Lamps

To the Editor:

The paper "Some Characteristics and Applications of Negative-Glow Lamps" by H. M. Ferree (*AIEE Trans., Jan. '41, p. 8*) does not include applications of glow tubes which deserve mention.

As Mr. Ferree mentioned, these glow lamps have the characteristic of illumination at the negative electrode, but he failed to state that the area of surface of electrode covered by the glow is, in the normal region, directly proportioned to the current. This characteristic makes the glow lamp applicable to use with an oscilloscope when the tube is viewed with a rotating mirror. The high breakdown and extinction potentials of these tubes mean that part of an impressed electric wave would be "cut off" (distorted by the oscilloscope). To avoid this difficulty it is common to excite the tube continuously with a high-frequency discharge so that only a small impressed potential is sufficient to cause the tube to glow. To make the tube satisfactory for viewing alternating currents the tube is made with two long colinear electrodes with a short spacing. The distance the electrode illuminates, measured from the electrode gap, is a measure of the magnitude of the instantaneous current. If the current is periodic the wave shape of the current may be seen by viewing the tube with the aid of a rotating mirror. Such an oscilloscope has been made.[1]

A second application of the glow tube is as a surge protector. If the field circuit of a magnet is opened suddenly a very high voltage will be induced in the windings. When a glow tube with a breakdown voltage somewhat higher than line voltage is placed across the field, the voltage across the field as the circuit is broken will not reach as high a value. The glow tube will begin to dissipate the energy in the magnetic field as soon as the voltage across the field exceeds the breakdown voltage. In tests made on a generator field it was found that (*a*) without a glow tube the voltage rose to 16 times normal and did not drop to zero until about 0.08 second, and (*b*) with a glow tube the voltage rose to 6.4 times normal and dropped to zero in less than 0.0025 second.[2]

A third application of the glow tube, familiar to all radio amateurs, is its use as a detector of a radio frequency circuit

In the list of references given by Mr. Ferree should be included the work of Oschwald and Tarrant[3] and of Reich[4] on the influence of light on the glow-tube characteristics. Reference might also be made to the use of the glow tube as a generator of saw-tooth oscillations,[5] even though this application has been almost superseded by the use of arc discharge tubes.

References

1. Neon Tube Oscilloscope as a Precision Servicing Instrument, **T. P. Hover.** *International Projectionist*, July 1937.

2. Littelfuse Laboratories, Chicago, Ill.; communication from E. V. Sundt.

3. **V. A. Oschwald and A. G. Tarrant,** *Proceedings* of the Physical Society, London, volume 36, 1924, page 241.

4. **H. J. Reich,** *Journal* of the Optical Society of America, volume 17, 1928, page 271.

5. The Oscilloscope—a Stabilized Cathode Ray, **F. Bedell and H. J. Reich.** Journal of the AIEE, volume 46, 1927, page 563 (see bibliography).

G. H. Fett (A'32, M'38)

(Department of electrical engineering, University of Illinois, Urbana)

Books Received •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ELECTRICAL MEASUREMENTS AND MEASURING INSTRUMENTS. By E. W. Golding. Third edition. Sir Isaac Pitman and Sons, London; Pitman Publishing Corporation, New York, 1940. 828 pages, illustrated, 9 by 5½ inches, cloth, $7.50. Originally designed to cover the knowledge required for certain British examinations, this textbook has been expanded to meet the requirements of electrical engineers in general. Covers theory and use of all types of electrical measuring instruments and methods, including the mathematical derivations for wave forms and transient phenomena. Contains reference bibliographies and examination questions with answers.

ELECTROMAGNETIC THEORY. By J. A. Stratton. McGraw-Hill Book Company, New York and London, 1941. 615 pages, diagrams, etc., 9 by 6 inches, cloth, $6.00. The author of this advanced text places primary emphasis on dynamic rather than on static field theory, postulating Maxwell's equations from the outset. A mathematical formulation of the general theory is followed by investigation of energy and stress relations. The properties of static fields are then discussed, and the rest of the book is devoted to the propagation of plane, cylindrical and spherical waves, the theory of radiation, and boundary-value problems. Illustrative problems.

EXPLORATION GEOPHYSICS. By J. J. Jakosky. Times-Mirror Press, Los Angeles, Calif., 1940. 786 pages, illustrated, 9 by 6 inches, cloth, $8.00. Aims to describe the fundamental theories, equipment, and field techniques of the recognized exploratory geophysical methods, and to illustrate their application to problems of economic geology. An early chapter presents the geologic and economic background, and succeeding chapters deal respectively with magnetic, gravitational, electrical, seismic, geochemical, and geothermal methods Drill-hole investigations and oil-well production problems are also considered. Literature references in text, and patent bibliography appended to each chapter.

GEOPHYSICAL EXPLORATION. By C. A. Heiland. Prentice-Hall, New York, 1940. 1,013 pages, illustrated, 9½ by 6 inches, cloth, $10.00. Intended as a comprehensive survey of the entire field of geophysical exploration. The elementary first part describes working principles and geological applications for those not directly concerned with field or laboratory operations. The second and major part discusses the subject from an engineering viewpoint, presenting theory, field technique, laboratory procedure and geological interpretations for gravitational, magnetic, seismic, and electrical methods. Consideration is also given to minor methods and to geophysical well testing.

HISTORY OF GEOMETRICAL METHODS. By J. L. Coolidge. Clarendon Press, Oxford, England; Oxford University Press, New York, 1940. 451 pages, diagrams, 10 by 6 inches, cloth, $10.00. The methods that men have invented throughout the centuries to deal with geometrical questions are considered under three main headings: synthetic geometry, the earliest type which considers figures directly; algebraic geometry, including co-ordinate systems; and differential geometry. The work of the important pioneers in each field has been emphasized. Bibliography.

HOUSING FOR DEFENSE, by M. L. Colean. Twentieth Century Fund, 330 West 42nd Street, New York, 1940. 198 pages, diagrams, 9½ by 6 inches, paper, $1.50. The problems and experience with regard to housing during the World War are described, with attention to the resulting government policies. The present situation is compared with that of 1917–18. The relation between housing and the location of defense activities is emphasized, and community problems are discussed. The final chapters deal with the construction and financing of new housing, the relative parts to be played by private and governmental agencies, and the recommendations of the housing committee.

LOCOMOTIVES ON PARADE. By E. Hungerford. Thomas Y. Crowell Company, New York, 1940. 236 pages, illustrated, 9 by 6½ inches, cloth, $2.50. The history of the steam locomotive told in layman's language, describing the successive types that evolved, including famous individual representatives and the men who made them.

THE METER AT WORK. By J. F. Rider. John F. Rider Publisher, New York, 1940. 152 pages, illustrated, 9 by 5 inches, cloth, $1.25. This practical book for servicemen and others describes how each type of meter works, how each is used in the field, how to increase efficiency, and how to select new meters. In an unusual method of book construction, the illustrations are placed above and separate from the text for convenient reference.

MODERN AIR CONDITIONING, HEATING, AND VENTILATING. By W. H. Carrier, R. E. Cherne, and W. A. Grant. Pitman Publishing Corporation, New York and Chicago, 1940. 547 pages, illustrated, 9½ by 6 inches, cloth, $4.50. The whole field of interior conditioning is covered in this manual, which is designed to apply existing theory to actual practice in the industry. Basic theories are explained, but emphasis is placed on the engineering principles and design of equipment. Comfort and economic factors are also considered. Practical examples are presented, and tables and charts collected in an appendix.

NATIONAL ELECTRICAL CODE HANDBOOK. By A. L. Abbott. Fifth edition. McGraw-Hill Book Company, New York and London, 1940. 595 pages, illustrated, 7½ by 4½ inches, leather, $3.00. Discusses the provisions of the National Electrical Code and their practical application. These provisions are grouped in six major divisions: definitions of terms; approved types of wiring; installation of materials and apparatus; general requirements applying to all wiring systems; special cases; and construction of materials. The present edition is based on the 1940 Code.

PHYSICS OF THE AIR. By W. J. Humphreys. Third edition. McGraw-Hill Book Company, New York, 1940. 676 pages, illustrated, 9½ by 6 inches, cloth, $6.00. Provides an account of the facts and theories relating to the mechanics and thermodynamics of the atmosphere, to atmospheric electricity, acoustics, and optics, and to the factors that control climate. Revised to include recent information.

POWER IN TRANSITION. By E. R. Abrams. Charles Scribner's Sons, New York, 1940. 318 pages, maps, tables, 8½ by 5½ inches, cloth, $3.00. Describes briefly the development of the electric utilities up to the peak of private operation; then considers the growing tendency toward public control. Some 60 major power projects are analyzed, with their history through Congress engineering problems and the resources, requirements, and expectations of the several regions to be served. Probable effects of these developments of the national power policy are briefly pointed out. Chapter bibliographies.